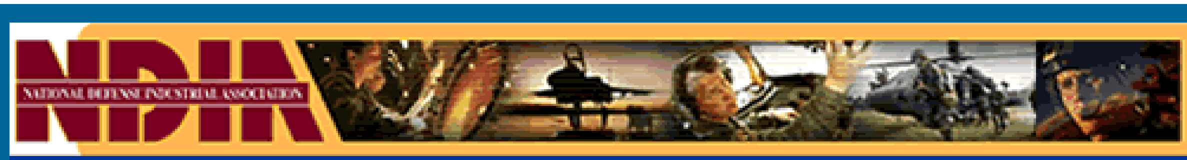


24th ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

"Test and Evaluation of Autonomous Systems & The Role of the T&E Community in the Requirements Process"

PALM SPRINGS, CA

FEBRUARY 25 - 28, 2008

Agenda

MONDAY, FEBRUARY 25, 2008

SESSION A

"Combinatorial Testing: Required Knowledge in a World Where Traversing Every Possible Path is Impossible," Dr. Mark Kiemele, President and Cofounder, Air Academy Associates

SESSION B

"System Evaluation of UAVs," Dr. Juan A. Vitali, Chief, T&E, Joint PEO Chem Bio Defense

TUESDAY, FEBRUARY 26, 2008

SESSION A

Unmanned Systems: What's New, What's Not?

- Mr. Gene Fraser, Vice President, Northrop Grumman Unmanned Systems
- Mr. Allen Nease, Chief, Robotics, Tyndall AFB

Government Keynote Address: Hon Charles E. McQueary, Director OT&E, OSD

SESSION B

- Maj Gen Stephen T. Sargeant, USAF, Commander, Air Force Operational T&E Command (AFOTEC)
- RDML Stephen Voetsch, USN, Commander, Navy Operational T&E Force (OPTEVFOR)
- Dr. James Streilein, Technical Director, Army T&E Command (ATEC)
- Mr. Stephen Daly, Deputy Director, ODOT&E, OSD

Luncheon Address: "Motivating Young Americans to Pursue Robotics Technology," Mr. Marco Ciavolino, President, Enktesis, LLC

SESSION C

- "Unique Range Challenges of UAV/RPV/UUV Test and Evaluation," RDML David Dunaway, USN, Commander, Naval Air Warfare Center, Weapons Division, China Lake, AIR 5.0 Assistant Commander for T&E "Airspace Management Issues for UAVs, RPVs," Mr. Jeffrey "Goldy" Goldfi nger, ASTM Committee F38 Vice Chairman, L-3 Communications, Inc.

CONCURRENT FOCUS SESSION D

T&E ROLE IN SYSTEM REQUIREMENTS

- "Interoperability Testing in a Net Centric Environment; The Role of the Test Community in Development and Assessment of System-of-System Requirements," Mr. Frank Alvidrez, MTSI Corporation
- "Automatic Generation of Requirement Specifi cations (Verifi cation)," Mrs. Monika Morgan, General Dynamics Land Systems
- "Improving Requirements & Testing Process for Rapidly Fielded Unmanned Aircraft System Program," Mr. Jeremy S. Dusina, U.S. Army Evaluation Center
- "Individual Protection in a CBRN Environment: Case Studies of the Role of T&E in Requirements Generation," Ms. Karen McGrady, JPM Individual Protection

T&E POLICY ISSUES

- “Application of MIL-HDBK-189 Reliability Growth Analysis (RGA) on Mobile Gun System (MGS) Product Verification Test (PVT),” Dr. Dmitry Tananko, General Dynamics Land Systems
- “Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives,” Mr. Frank Parker, General Services Administration
- “Applicability of Evolutionary Strategies for Acquisition of Autonomous Systems,” Dr. Ebru Sarigol, STM AS, Turkey
- “Unmanned Systems Safety Guide for DoD Acquisition,” Mr. Michael Demmick, NOSSA, N314, WSESRB
- “Unmanned Vehicle Synthetic Environment,” Mr. Angelo Prevete, Lockheed Martin Corporation

OT&E CHALLENGES

- “Operational Testing (OT) and Unmanned Aerial Vehicles,” Mr. Curt Cook, ODOT&E, OSD
- “Test Pilot’s Role in Flight Test of Unmanned Vehicles,” Mr. Roy Martin, Northrop Grumman Corporation
- “Testing in a Joint Environment Measures Framework,” Mr. Max Lorenzo, JTEC
- “Challenges for Testing in Defense System of Systems Environment,” Dr. Judith Dahmann, MITRE Corporation
- “Evaluating Autonomy of UAVs,” Dr. Herbert Hecht, SoHar, Inc.

WEDNESDAY, FEBRUARY 27, 2008

Former DOT&E’s Weigh-in on T&E Issues

- Hon Philip E. Coyle, III, Director OT&E (1994 – 2001)
- Hon Thomas Christie, Director OT&E (2001 – 2006)

NDIA Industrial Committee on Operational T&E (ICOTE) Update from the Chairman, Mr. Larry Graviss, President, Eagle Engineering, Inc.

SESSION F – CONFERENCE TOWN MEETING
Chairs: Dr. Paul H. Deitz, HRED, ARL and Mr. Britt Bray, DRC Corporation

SESSION G – GOVERNMENT STUDIES / REPORTS IMPACTING THE T&E COMMUNITY

- “Opportunities to Optimize the Operational Use of Unmanned Systems and Gain Synergy in Developing New Capabilities,” Ms. Sharon Pickup, GAO, DC and Mr. Michael Sullivan, GAO, Dayton

CONCURRENT FOCUS SESSION H

T&E ANALYTICAL APPROACHES

- Live, Virtual, and Constructive Simulation Use for Unmanned Vehicle Requirements and T&E,” Mr. Gary Kollmorgen, Referentia
- “The Four Element Framework: Progress Towards an Integrated and Mission-based T&E Strategy,” Mr. Chris Wilcox, Army Evaluation Center
- “An Enterprise Environment for Information Assurance / Computer Network Defense T&E,” Mr. Steve Moore, Booz Allen Hamilton
- “Applying Design of Experiments Methodology to Sortie Generation Rate T&E,” Mr. Joseph Tribble, AVW Technologies

TEST INSTRUMENTATION / DATA COLLECTION / ARCHITECTURE

- “TRIZ and Measurement and Detection Problems,” Mr. Michael Slocum, Air Academy Associates
- "Time Space Position Information (TSPI) T&E Instrumentation Technology Investment Plan – Ensuring T&E Ranges Can Meet the Test Requirements of the Future,” Mr. Dick Dickson, Tybrin Corporation“Semi-Autonomous Delivery Transport Vehicle for Undersea Sensors System Integration Testing Results Lessons-Learned,” Mr. Pete Reinagel, SYS Technologies
- “Test and Training Enabling Architecture, TENA, an Important Component in Joint Mission Environment Test Capability (JMETC) Successes,” Mr. Gene Hudgins, BAE Systems
- “Preserving Critical Knowledge,” Mr. Roy Weber, VSE Corporation

T&E ROLE IN SYSTEM REQUIREMENTS

- “Warfare Systems Engineering Challenges and T&E Approaches,” Mr. Robert Connerney, Naval Undersea Warfare Center Division, Newport
- “Integrating T&E into DoD Acquisition Contracts,” Ms. Darlene Mosser-Kerner, OUSD (AT&L)
- “Improving T&E Participation in the Requirements Generation Process,” Mr. Keith Montgomery, Lockheed Martin Corporation

THURSDAY, FEBRUARY 28, 2008

“UAVs On-campus R&D,” Dr. Steve Hottman, Physical Sciences Lab, Associate Dean, New Mexico State University

SESSION I – REPORTS FROM THE COMBAT ZONE: OIF & OEF

- “ATEC Forward Operational Assessment Team,” COL Mark Mills, USA, U.S. Army ATC
- “Lessons Learned in Fielding a UAS RQ4A Global Hawk in the Combat Theater,” Mr. Sam McKeehan, Northrop Grumman Corporation

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

PROMOTING NATIONAL SECURITY SINCE 1919

24th Annual

NATIONAL TEST & EVALUATION CONFERENCE

"Test and Evaluation of Autonomous Systems & The Role of the T&E Community in the Requirements Process"

PRESENTERS INCLUDE:

- Hon Charles McQueary, DOT&E
- Gen Larry Welch, USAF (Ret)
- Hon Thomas Christie, Former DOT&E
- Hon Philip Coyle, III, Former DOT&E
- Mr. Dick Rutan, Aviator and Entrepreneur

Sponsored by the T&E Division, NDIA and Co-sponsored by ASTM and the Aircraft Survivability, Combat Survivability and Robotics Divisions, NDIA

ASTM INTERNATIONAL

HILTON PALM SPRINGS, PALM SPRINGS, CA

FEBRUARY 25-28, 2008

EVENT #8910 **CONFERENCE PROGRAM** **WWW.NDIA.ORG/MEETINGS/8910**

MONDAY, FEBRUARY 25, 2008

9:00AM – 5:00PM Conference Registration **– Horizon Foyer**

TUTORIAL SESSIONS

▶ **Plaza AB** ▶ **Plaza CD**

	SESSION A	SESSION B
1:30PM	1) "Combinatorial Testing: Required Knowledge in a World Where Traversing Every Possible Path is Impossible," *Dr. Mark Kiemele, President and Cofounder, Air Academy Associates*	2) "Survivability of Unmanned Systems," *Dr. Albert Moussa, President, BlazeTech, Inc.*
3:00PM	Afternoon Break	Afternoon Break
3:15PM	1 Cont.) "Combinatorial Testing: Required Knowledge in a World Where Traversing Every Possible Path is Impossible," *Dr. Mark Kiemele, President and Cofounder, Air Academy Associates*	3) "System Evaluation of UAVs," *Dr. Juan A. Vitali, Chief, T&E, Joint PEO Chem Bio Defense*

Tutorial Sessions are provided free of charge to all those registering for the conference. Your attendance at these valuable tutorials is encouraged.

5:00PM – 6:00PM Evening Reception / Display Area Open **– Horizon Ballroom**

6:00PM Display Area Closed for the Day / Conference Adjourned for the Day

TUESDAY, FEBRUARY 26, 2008

7:00AM – 5:00PM Conference Registration Open **– Horizon Foyer**

7:00AM – 8:00AM Continental Breakfast in Display Area **– Horizon Ballroom**

SESSION A
Chair: Mr. James O'Bryon, Chairman, NDIA T&E Division

8:00AM Call to Order and Remarks **– Plaza Ballroom**, *Mr. Sam Campagna, Director, Operations, NDIA*

8:05AM Tribute to our Nation and Fighting Forces, National Anthem

8:10AM Welcome and Conference Introductory Remarks, *Mr. James O'Bryon, Chairman, NDIA T&E Division*

CONFERENCE KICKOFF CAUCUS

8:15AM	Unmanned Systems: What's New, What's Not? Chair: *VADM Joseph Dyer, USN (Ret), Executive Vice President & General Manager, iRobot Corporation*

- *Mr. Gene Fraser, Vice President, Northrop Grumman Unmanned Systems*
- *Mr. Michael Gaulke, Chairman and CEO, Exponent Corporation*
- *RADM Timothy Heely, USN, PEO Unmanned Systems, NAVAIR*
- *Mr. Allen Nease, Chief, Robotics, Tyndall AFB*

9:15AM	Government Keynote Address: *Hon Charles E. McQueary, Director OT&E, OSD*
9:45AM	Military Perspectives Keynote Address: *General Larry D. Welch, USAF (Ret), President, IDA, Former Chief of Staff, USAF*
10:15AM	Morning Break & Networking in Display Area **– Horizon Ballroom**

SESSION B
Chair: Dr. Juan A. Vitali, Chief, T&E, Joint PEO Chem Bio Defense

10:45AM	OTAs Roundtable: "Applying the T&E Requirements Process to Unmanned / Autonomous Vehicles"

- *Maj Gen Stephen T. Sargeant, USAF, Commander, Air Force Operational T&E Command (AFOTEC)*
- *RDML Stephen Voetsch, USN, Commander, Navy Operational T&E Force (OPTEVFOR)*
- *Col Michael S. Bohn, USMC, Commander, U.S. Marine Corps Operational T&E Activity (MCOTEA)*
- *Dr. James Streilein, Technical Director, Army T&E Command (ATEC)*
- *Mr. Stephen Daly, Deputy Director, ODOT&E, OSD*

12:15PM – 1:15PM	Luncheon **– Horizon Ballroom**: "Motivating Young Americans to Pursue Robotics Technology," *Mr. Marco Ciavolino, President, Enktesis, LLC*

A Roomba will be given away to benefit students of TechBrick Robotics. TeckBrick is a robotics club formed in 2003 for home schoolers in the Baltimore, MD area. This year, TechBrick has four U.S. FIRST competition teams with a total of 30 students and 5 adult coaches. Over the past 4 years, TechBrick has helped train more than 40 young engineers-to-be through the robotics program offered by FIRST. To view more information, please visit www.techbrick.com.

SESSION C
Chair: Dr. Paul H. Deitz, Acting Director, HRED, ARL

1:30PM	"Unique Range Challenges of UAV/RPV/UUV Test and Evaluation," *RDML David Dunaway, USN, Commander, Naval Air Warfare Center, Weapons Division, China Lake, AIR 5.0 Assistant Commander for T&E*
1:55PM	"Airspace Management Issues for UAVs, RPVs," *Mr. Jeffrey "Goldy" Goldfinger, ASTM Committee F38 Vice Chairman, L-3 Communications, Inc.*
2:20PM	Afternoon Break & Networking in Display Area **– Horizon Ballroom**

CONCURRENT FOCUS SESSION D

	▶ Plaza AB	▶ Plaza CD	▶ Palm Canyon AB
	D1) T&E ROLE IN SYSTEM REQUIREMENTS *Chair: Dr. Lowell Tonnessen, IDA*	**D2) T&E POLICY ISSUES** *Chair: Mr. Dick Dickson, Tybrin Corporation*	**D3) OT&E CHALLENGES** *Chair: RADM "Bert" Johnston, USN (Ret), Wyle Laboratories*
2:30PM	"How Early Involvement Can Benefit the Requirements Generation Process for UAV Ground Checkout and Maintenance," *Mr. Steven Madison, Northrop Grumman Corporation*	"Application of MIL-HDBK-189 Reliability Growth Analysis (RGA) on Mobile Gun System (MGS) Product Verification Test (PVT)," *Dr. Dmitry Tananko, General Dynamics Land Systems*	"Operational Testing (OT) and Unmanned Aerial Vehicles," *Mr. Curt Cook, ODOT&E, OSD*
3:00PM	"Interoperability Testing in a Net Centric Environment; The Role of the Test Community in Development and Assessment of System-of-System Requirements," *Mr. Frank Alvidrez, MTSI Corporation*	"Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives," *Mr. Frank Parker, General Services Administration*	"Test Pilot's Role in Flight Test of Unmanned Vehicles," *Mr. Roy Martin, Northrop Grumman Corporation*
3:30PM	"Automatic Generation of Requirement Specifications (Verification)," *Mrs. Monika Morgan, General Dynamics Land Systems*	"Applicability of Evolutionary Strategies for Acquisition of Autonomous Systems," *Dr. Ebru Sarigol, STM AS, Turkey*	"Testing in a Joint Environment Measures Framework," *Mr. Max Lorenzo, JTEC*
4:00PM	"Improving Requirements & Testing Process for Rapidly Fielded Unmanned Aircraft System Program," *Mr. Jeremy S. Dusina, U.S. Army Evaluation Center*	"Unmanned Systems Safety Guide for DoD Acquisition," *Mr. Michael Demmick, NOSSA, N314, WSESRB*	"Challenges for Testing in Defense System of Systems Environment," *Dr. Judith Dahmann, MITRE Corporation*
4:30PM	"Individual Protection in a CBRN Environment: Case Studies of the Role of T&E in Requirements Generation," *Ms. Karen McGrady, JPM Individual Protection*	"Proteus Testbed Utilized to Flight Test New Global Hawk Radar," *Mr. David Brown, Northrop Grumman Corporation*	"Evaluating Autonomy of UAVs," *Dr. Herbert Hecht, SoHar, Inc.*
5:00PM		"Unmanned Vehicle Synthetic Environment," *Mr. Angelo Prevete, Lockheed Martin Corporation*	"Deployability and Survivability Testing for the Deployable Autonomous Distributed System (DADS)," *Mr. Steve Whiteside, SPAWAR*

5:30PM	Display Area Closed for the Day / Conference Adjourned for the Day
6:30PM – 8:30PM	Walter W. Hollis Honors Banquet **– Horizon Ballroom** *Presentation of the Walter W. Hollis Award for outstanding lifetime achievement in defense Test & Evaluation.*

Recipient:
Dr. Paul H. Deitz, Acting Director HRED, ARL, APG, MD

In his early RDT&E work at the Ballistic Research Laboratories, Dr. Deitz distinguished himself in laser scintillation testing and eye-damage modeling studies and later in evaluations of smart weapons. Over the ensuing two decades, his seminal work in ballistic live-fire simulation and testing has contributed to improved vulnerability/survivability of our front-line combat platforms.

Dr. Deitz is a prolific writer, publishing numerous papers examining the detailed measures of simulation and testing, providing clarity and mutual synergism to the benefit of both disciplines. Over the past decade, Dr. Deitz has served as the Technical Director of AMSAA and the Acting Director of the Survivability/ Lethality Analysis Directorate, ARL.

He earned a BA in Physics from Gettysburg College and an MS and Ph.D. in Electrical Engineering from the University of Washington.

Guest Speaker:
Mr. Dick Rutan, Aviator and Entrepreneur

Mr. Dick Rutan made history in December of 1986 after completing Voyager's nine day, three minute and forty-four second flight around the world, non-stop and non-refueled, setting world records that remain unchallenged today. In July of 2002, Mr. Rutan was inducted into the National Aviation Hall of Fame in Dayton, OH. As a youth, he was fascinated by airplanes and flying and made his first flight at age six. He received his solo pilot's license and driver's license on his 16th birthday; the first possible moment he could be pilot in command.

Retired from the United States Air Force as a Lieutenant Colonel, Mr. Rutan flew 325 missions in Vietnam, 105 of them as a member of the Super Sabre FAC, a high-risk operation commonly known as the "MISTY's." He was hit by enemy ground fire on his last mission and was forced to eject from his burning F-100, to be rescued later.

Before retiring from the Air Force in 1978, Mr. Rutan was awarded the Silver Star, five Distinguished Flying Crosses, 16 Air Medals and a Purple Heart. Today, he travels the world lecturing about his flights and aviation's future, stressing, "If you can dream it, you can do it!"

WEDNESDAY, FEBRUARY 27, 2008

7:00AM – 5:00PM	Conference Registration Open **– Horizon Foyer**
7:00AM – 8:00AM	Continental Breakfast in the Display Area **– Horizon Ballroom**

SESSION E
Chair: Dr. Mark Kiemele, President and Cofounder, Air Academy Associates

8:00AM — Call to Order and Remarks **– Plaza Ballroom**, *Mr. Sam Campagna, Director, Operations, NDIA*

8:05AM — "Ground Robotics, Where Are We Headed?" *Ms. Ellen Purdy, Director, Joint Ground Robotics, OUSD (AT&L)*

8:35AM — Former DOT&E's Weigh-in on T&E Issues

- *Hon Philip E. Coyle, III, Director OT&E (1994 – 2001)*
- *Hon Thomas Christie, Director OT&E (2001 – 2006)*

9:35AM — NDIA Industrial Committee on Operational T&E (ICOTE) Update from the Chairman, *Mr. Larry Graviss, President, Eagle Engineering, Inc.*

10:00AM — Morning Break & Networking in the Display Area **– Horizon Ballroom**

SESSION F – CONFERENCE TOWN MEETING
Chairs: Dr. Paul H. Deitz, HRED, ARL and Mr. Britt Bray, DRC Corporation

10:30AM — The Role of T&E in the Requirements Process

- *Brig Gen Greg Feest, USAF, J8, Joint Chiefs of Staff*
- *Mr. Allan M. Resnick, Director of Requirements Integration Directorate, Army Capabilities Integration Center (ARCIC), Ft. Monroe*
- *Mr. James Ruma, Vice President, Engineering Programs, GDLS*
- *RADM Bill McCarthy, USN (Ret), DDOT&E / Net Centric Warfare*
- *Col Michael S. Bohn, USMC, Commander, U.S. Marine Corps Operational T&E Activity (MCOTEA)*

The Town Meeting is a unique forum used by the T&E Division to enable free and candid discussion of important, sometimes sensitive and controversial subjects. All comments made during the town meeting by both panelists and the audience are off the record and not for attribution to encourage candor and give-and-take on the topic at hand.

The issue being addressed this year is the role that the T&E community has, does and should play in the development, establishment and assessment of system requirements. Policies over the years have tended to keep the T&E community somewhat isolated from the requirements process due to the perceived potential conflict of interest.

With the growing emphasis on more rapid fielding, spiral development, acquisition reform, escalating costs and a host of other pressures on the acquisition process, a renewed discussion on the role of T&E in this process is overdue. Our distinguished participants will share their candid thoughts and debate this issue with each other, as well as fielding questions from the audience.

Members of the media are excluded from this session.

12:00PM – 1:00PM Annual Tester of the Year Awards Luncheon **– Horizon Ballroom**

2007 Tester of the Year Award Recipients:

OSD
Military: *COL Kurt Lambert, USA*
Civilian: *Ms. Darlene Mosser-Kerner*
Contractor: *Mr. Brent Crabtree*

OSD Special Category
Mine Resistant Ambush Protected Vehicle Joint Test Team

U.S. Air Force
Military: *Lt Col Shaun McGrath, USAF*
Civilian: *Mr. Clyde Shook*
Contractor: *Mr. Derrell Parker*

U.S. Army
Military: *MAJ Robert McClintock, USA*
Civilian: *Mr. Gregory Brewer*
Contractor: *Ms. Lori Keaty*

U.S. Marine Corps
Military: *Maj Stephen Augustin, USMC*
Civilian: *Mr. Paul Johnson*

U.S. Navy
Military: *LT Thomas Kneale, USN*
Civilian: *Mr. Mark Koromhas*
Contractor: *Ms. Susan Smola*

SESSION G – GOVERNMENT STUDIES / REPORTS IMPACTING THE T&E COMMUNITY
Chair: Mr. William Yeakel, President, ORSA Corporation

1:15PM Defense Science Board (DSB) Study Report

"Terms of Reference," *Mr. Christopher DiPetto, Executive Secretary, DSB, OUSD (A&T)*

"Synopsis of Results and Potential Impact of the DSB Report," *Mr. Charles "Pete" Adolph, Chair, DSB Study*

2:00PM Report of GAO Study of UAVs

"Opportunities to Optimize the Operational Use of Unmanned Systems and Gain Synergy in Developing New Capabilities," *Ms. Sharon Pickup, GAO, DC and Mr. Michael Sullivan, GAO, Dayton*

2:30PM Afternoon Break & Networking in Display Area – **Horizon Ballroom**

CONCURRENT FOCUS SESSION H

	▶ **Plaza AB**	▶ **Plaza CD**	▶ **Palm Canyon AB**
	H1) T&E ANALYTICAL APPROACHES *Chair: Dr. Anne Hillegas, Applied Research Associates, Inc.*	**H2) TEST INSTRUMENTATION / DATA COLLECTION / ARCHITECTURE** *Chair: Mr. Britt Bray, DRC Corporation*	**H3) T&E ROLE IN SYSTEM REQUIREMENTS** *Chair: Mr. Charles Larson, SURVICE Engineering*
3:00PM	"Live, Virtual, and Constructive Simulation Use for Unmanned Vehicle Requirements and T&E," *Mr. Gary Kollmorgen, Referentia*	"TRIZ and Measurement and Detection Problems," *Mr. Michael Slocum, Air Academy Associates*	"Suitability-Effectiveness Trade-Off Economics," *Dr. Donald Gaver, Naval Postgraduate School, Operations Research Department*
3:25PM	"Root Cause Analysis & Evaluation of the Stryker Remote Weapon Station Inhibit Zone Violation Using a Six Sigma Approach," *Mr. David Cafagna, General Dynamics Land Systems*	"Time Space Position Information (TSPI) T&E Instrumentation Technology Investment Plan – Ensuring T&E Ranges Can Meet the Test Requirements of the Future," *Mr. Dick Dickson, Tybrin Corporation*	"Warfare Systems Engineering Challenges and T&E Approaches," *Mr. Robert Connerney, Naval Undersea Warfare Center Division, Newport*
3:50PM	"The Four Element Frame-work: Progress Towards an Integrated and Mission-based T&E Strategy," *Mr. Chris Wilcox, Army Evaluation Center*	"Semi-Autonomous Delivery Transport Vehicle for Undersea Sensors System Integration Testing Results Lessons-Learned," *Mr. Pete Reinagel, SYS Technologies*	"Integrating T&E into DoD Acquisition Contracts," *Ms. Darlene Mosser-Kerner, OUSD (AT&L)*
4:15PM	"An Enterprise Environment for Information Assurance / Computer Network Defense T&E," *Mr. Steve Moore, Booz Allen Hamilton*	"Test and Training Enabling Architecture, TENA, an Important Component in Joint Mission Environment Test Capability (JMETC) Successes," *Mr. Gene Hudgins, BAE Systems*	"Incorporating T&E into Your Requirements Process," *Mr. David Henry, Lockheed Martin Corporation*
4:40PM	"Applying Design of Experiments Methodology to Sortie Generation Rate T&E," *Mr. Joseph Tribble, AVW Technologies*	"Preserving Critical Knowledge," *Mr. Roy Weber, VSE Corporation*	"Improving T&E Participation in the Requirements Generation Process," *Mr. Keith Montgomery, Lockheed Martin Corporation*

5:05PM Display Area Closed for the Day / Conference Adjourned for the Day

THURSDAY, FEBRUARY 28, 2008

7:00AM – 12:00PM	Conference Registration Open **– Horizon Foyer**
7:00AM – 8:00AM	Continental Breakfast in Display Area **– Horizon Ballroom**
8:00AM	Call to Order and Remarks **– Plaza Ballroom**, *Mr. Sam Campagna, Director, Operations, NDIA*
8:05AM	"UAVs On-campus R&D," *Dr. Steve Hottman, Physical Sciences Lab, Associate Dean, New Mexico State University*

SESSION I – REPORTS FROM THE COMBAT ZONE: OIF & OEF

8:30AM	"Prevention of Fratricides and Overkills Using UASs in Network Centric Warfare Operations," *Mr. Stan Nair, U.S. Army Evaluation Center*
	"Global Hawk Concept to Combat; T&E Lessons Learned," *Mr. Robert Ettinger, Northrop Grumman Corporation*
	"ATEC Forward Operational Assessment Team," *COL Mark Mills, USA, U.S. Army ATC*
10:00AM	Morning Break & Networking in Display Area **– Horizon Ballroom**
10:30AM	Display Area Closed
10:30AM	"Lessons Learned in Fielding a UAS RQ4A Global Hawk in the Combat Theater," *Mr. Sam McKeehan, Northrop Grumman Corporation*

SESSION J – CONFERENCE SYNTHESIS: ACTIONS AND TAKEAWAYS
Chair: Dr. Ernest Seglie, Science Advisor, DOT&E

11:00AM

- *Mr. Christopher DiPetto, Deputy Director, Systems & Software Engineering, OUSD (A&T)*
- *Mr. David Duma, Principal Deputy, ODOT&E*
- *Maj Gen George Harrison, USAF (Ret), Georgia Tech Research Institute*
- *Dr. James Streilein, Technical Director, Army T&E Command*
- *Mr. Steven K. Whitehead, Executive Director, Navy OPTEVFOR*

The discussion of this panel on the overall thrust of the conference will serve as the basis of a White Paper and an Overview article to be published in NDIA's National Defense Magazine.

11:55AM	Closing Remarks, *Mr. James O'Bryon, Chairman, NDIA T&E Division*
12:00PM	Conference Adjourned

WALTER W. HOLLIS HONORS BANQUET

The Walter W. Hollis Award is presented annually in recognition of lifetime contributions and achievement in the area of defense Test & Evaluation. The Award is presented in the name of Walter W. Hollis who is recognized for his dedicated and long-standing service in the field of Test & Evaluation.

Previous recipients include:

- *Mr. James F. O'Bryon, Former DDOT&E / LFT (2007)*
- *RADM Bert Johnston, USN (Ret), Wyle Laboratories (2006)*
- *Hon Thomas Christie, DOT&E, OSD (2005)*
- *Dr. Marion Williams, HQ AFOTEC (2004)*
- *Mr. James Fasig, Aberdeen Test Center (2003)*
- *Mr. G. Thomas Castino, Underwriters Laboratories, Inc. (2002)*
- *Hon Philip Coyle, III, DOT&E, OSD (2001)*
- *Mr. Walter Hollis, Department of the Army (2000)*

TESTER OF THE YEAR AWARDS LUNCHEON

The awards, presented to outstanding individuals in the field of Test & Evaluation, offer OSD and each Military Service Test & Evaluation Department the opportunity to select three award recipients for recognition as the Tester of the Year in specific categories. The three categories recognized are: Military, Civilian and Contractor.

T&E EXECUTIVE COMMITTEE

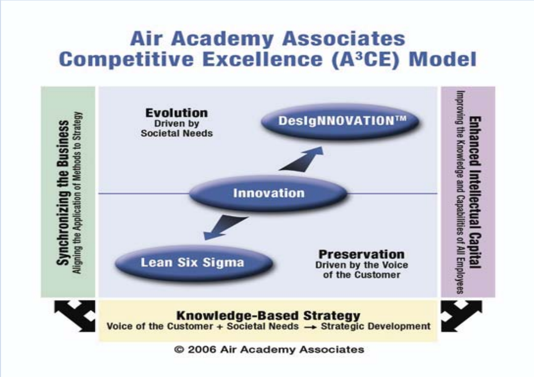
- *Mr. Joe Andrese, APG*
- *Mr. Dennis Bely, ARL*
- *Dr. Keith Bradley, LLNL*
- *Mr. Brit Bray, DRC Corporation*
- *RADM David Crocker, USN (Ret), CSC*
- *Dr. Paul Deitz, HRED*
- *Mr. Dick Dickson, Tybrin Corporation*
- *Mr. Russ Hauck, National Center for Simulation*
- *Dr. Anne Hillegas, ARA, Inc.*
- *Mr. John Illgen, Northrop Grumman Corporation*
- *RADM "Bert" Johnston, USN (Ret), Wyle Laboratories*
- *Dr. Mark Kiemele, Air Academy Associates*
- *Mr. Chuck Larson, SURVICE Engineering*
- *Mr. James O'Bryon, The O'Bryon Group*
- *Dr. Ernest Seglie, ODOT&E*
- *Mr. Jack Sheehan, FCSCTO*
- *Dr. Lowell Tonnessen, IDA*
- *Dr. Juan Vitali, JPEO-CBD, OSD*
- *Mr. Tom Wissink, Lockheed Martin Corporation*
- *Mr. Bill Yeakel, ORSA Corporation*

THANK YOU TO OUR PROMOTIONAL PARTNER

AIR ACADEMY ASSOCIATES

Air Academy Associates specializes in simplifying the disciplined and meticulous use of powerful tools and methodologies such as Design of Experiments/Multivariate Testing, High Throughput Testing (HTT), and Design for Six Sigma. DOE provides more information per data point collected than any other method and is a key to developing robust designs. HTT, a method for reducing the number of test cases while still maintaining adequate test coverage, focuses on constructing the most useful test combinations from a large number of variables, each with many possible options. Design for Six Sigma enables organizations to decrease time to market by 25 % to 40% which results in overall cost savings of 20% to 40% due to the utilization of fewer resources. Using data and a DFSS scorecard, we help clients zero in on the most likely causes of failure rather than relying on conjecture.

Our Competitive Excellence Model provides our clients with the plan, strategy, and tactics – including the methods, tools, and techniques – needed to preserve market share, profitability, and brand recognition and to enable the client organization to evolve by developing new life cycle curves for new products/ services or new generations of products/services. Our A3CE model, which has at its foundation our Knowledge Based Strategy, incorporates Lean, Six Sigma, and Systematic Tactical Innovation as Preservation activities and Design for Six Sigma and Systematic Strategic Innovation as Evolution activities.



Air Academy Associates provides value to our customers by:

- Educating leaders in our proven Knowledge-Based Business Strategy which emphasizes Voice of the Customer, Strategic Planning, and Systematic Innovation.
- Customizing our support and materials based on the client needs.
- Utilizing mature and experienced consultants who are proficient at problem-solving and who excel as classroom instructors and knowledge transfer agents.
- Incorporating advanced methods and techniques such as Robust Design, Tolerance Allocation, Expected Value Analysis, Axiomatic Design, etc., into our programs to optimize current performance and to enhance design and development phases.
- Developing supplemental strategic alliances to insure that our clients' needs are met.

For additional information, please contact an Air Academy Associates Business Development representative at 1-800-748-1277 or visit www.airacad.com.

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

2111 WILSON BOULEVARD
SUITE 400
ARLINGTON, VA 22201-3061
(703) 522-1820
(703) 522-1885 FAX
WWW.NDIA.ORG

THANK YOU FOR ATTENDING

WE LOOK FORWARD TO SEEING YOU NEXT YEAR IN ATLANTIC CITY MARCH 2-5, 2009

Air Academy Associates
Simplify, Perfect, Innovate

ASTM International

24th Annual
NATIONAL TEST & EVALUATION CONFERENCE

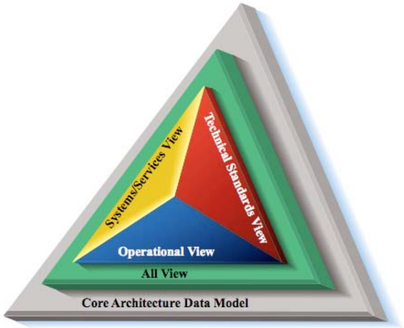
FEBRUARY 25-28, 2008

Interoperability Testing in a NetCentric Environment

Use of DoDAF & SysML Profile
in the Flight Test Environment

F. C. Alvidrez

MTSI - Edwards AFB



Topics

- Background, Introduction & Acknowledgements
- Why are we here?
  - Transformation & the Growth of NetCentric Warfare
  - Growth of NetCentric Warfare
  - System of Systems Engineering
- Interoperability Requirements
  - Integrated Architectures
  - NR-KPPs
  - DISA & JITC
- Approach to Testing
  - Example
- Summary

Background & Introduction

- Some Acknowledgements
  - DAU
  - DISA
  - DoDAF Working Group
  - OMG
- Some Caveats
  - Not an official USAF or USG presentation
  - All Material is available on line through DAU, DISA, and other public DoD Sources

QuickTime™ and a decompressor are needed to see this picture.

QuickTime™ and a decompressor are needed to see this picture.

Interoperability

If you are not interoperable, you are…

<u>Not</u> on the net

<u>Not</u> contributing

<u>Not</u> benefiting

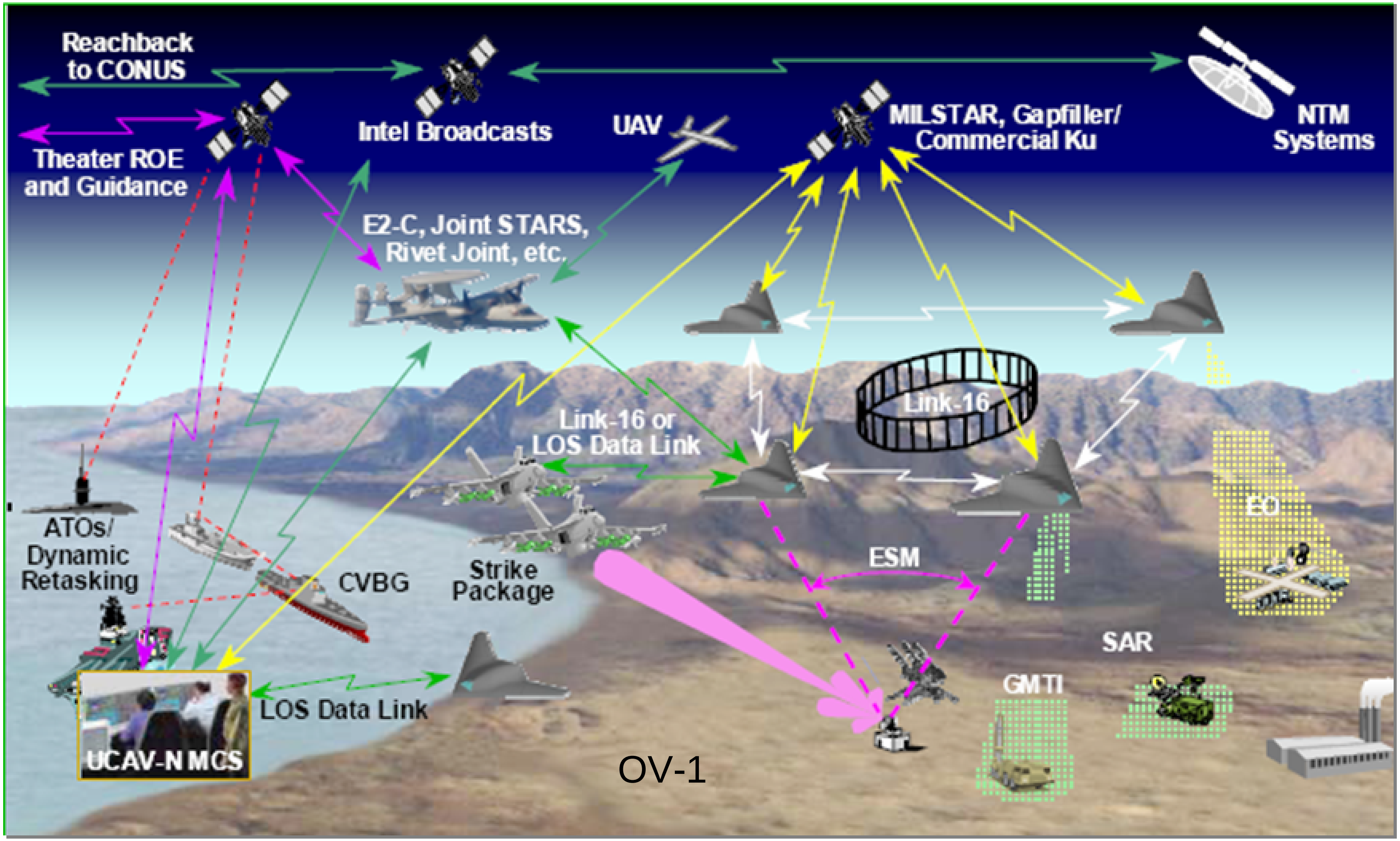
Not part of the <u>information age</u>

Source: USN War College NetCentric Warfare Presentation

Why DoDAF and Interoperability Test?

- Increasing NetCentric upgrades and modifications since 9/11 (actually starting after Iraq 1)
- Link-16, FAB-T, B-1B FIDL, B-52 CONECT, B-2A EHF, etc.,
- Requirement to shorten the “Kill Chain” and to increase Situational Awareness
- Interoperability is about Integrated Architectures
- DoDAF is the language of Integrated Architectures in DoD
- DoDAF Integrated Architectures is the blueprint for Interoperability Test Requirements

Interoperability Concept

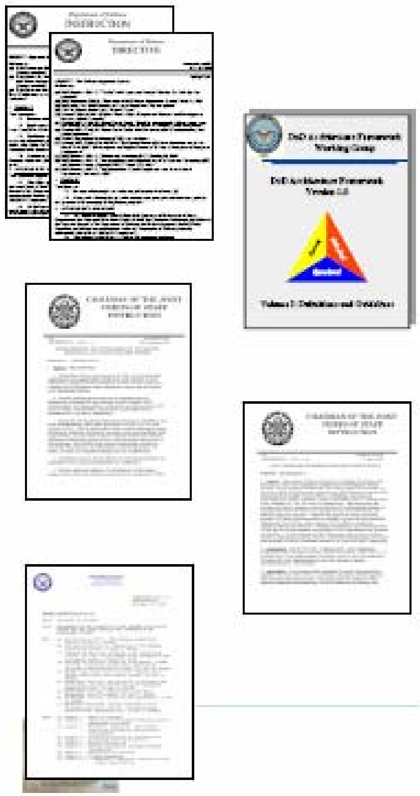


Source: DARPA J-UCAS 2004

Type of Problems

- Interoperability - Systems work at the subsystem level but do not work when in an operational environment
- Integration problems with legacy systems - Systems work but interfere with legacy systems such as IFF, TACAN or Defensive Avionics
- Lack of NetCentric & Interoperability Test expertise for early Test Planning -

DoDAF and DoD Policy



- **DoD 5000.1 and DoD 5000.2**
  - Establishes DoD acquisition policy
  - Requires select integrated architecture views at each milestone
  - Content and Scope of architecture products used is determined by MDA / PM
- **DoD Architecture Framework (DODAF) Document**
  - Provides basis for developing standardized architecture views and products required by DOD, CJCS, and SECNAV policy documents
- **CJCSI 3170.01E**
  - Requires the development of integrated architecture products for supporting acquisition documentations:
    - Joint Capability Integration and Development System (JCIDS)
    - Capability gap and redundancy analysis
- **CJCSI 6212.01C**
  - Requires architecture products be used in the J-6 interoperability and supportability certification process
  - Specifies which architecture products are required for the ICD, CDD, and CPD
- **SECNAV INST 5000.2C**
  - Establishes DON acquisition policy
  - Directs the PEO / PM to develop mission integrated architectures in support of the CDD/CPD process
  - Directs ASN (RD&A) CHENG to assist PMs in the development of operational and system architectural views.

DoD 4630 - All IT & NSS must be *tested for interoperability* before fielding, and the test results evaluated and *system certified* by DISA (JITC)

DoDAF & Mandatory Interoperability

DoD Dir. 4630.5 Interoperability and Supportability of Information (IT) and National Security Systems (NSS)

DoD 5000 Series – Defensive Acquisition System

Joint Capabilities Integration and Development System (JCIDS) CJCS 3710 Series

CJCSI 3180.01 Joint Requirements Oversight Council (JROC) Programmatic Process for Joint Experimentation and Joint Resource Change Recommendations

Others

How do you ensure interoperability? – Compliant DoDAF Architectures

DoD Architecture Framework Purpose & Scope

- Provide *guidance* on describing *architectures*
  - Warfighting Operations
  - Business Operations & Processes
- Provides guidance, rules & product descriptions for developing and presenting *"Integrated"* architectures
- Defines three views
  - Operational View
  - System View
  - Technical Standards

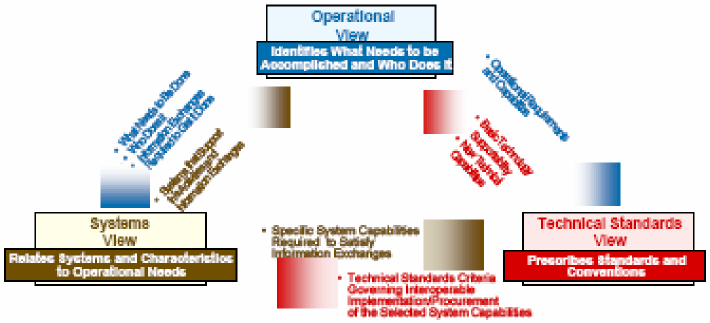


Figure 3-2. Fundamental Linkages Among the Views

The Linkages Between Views

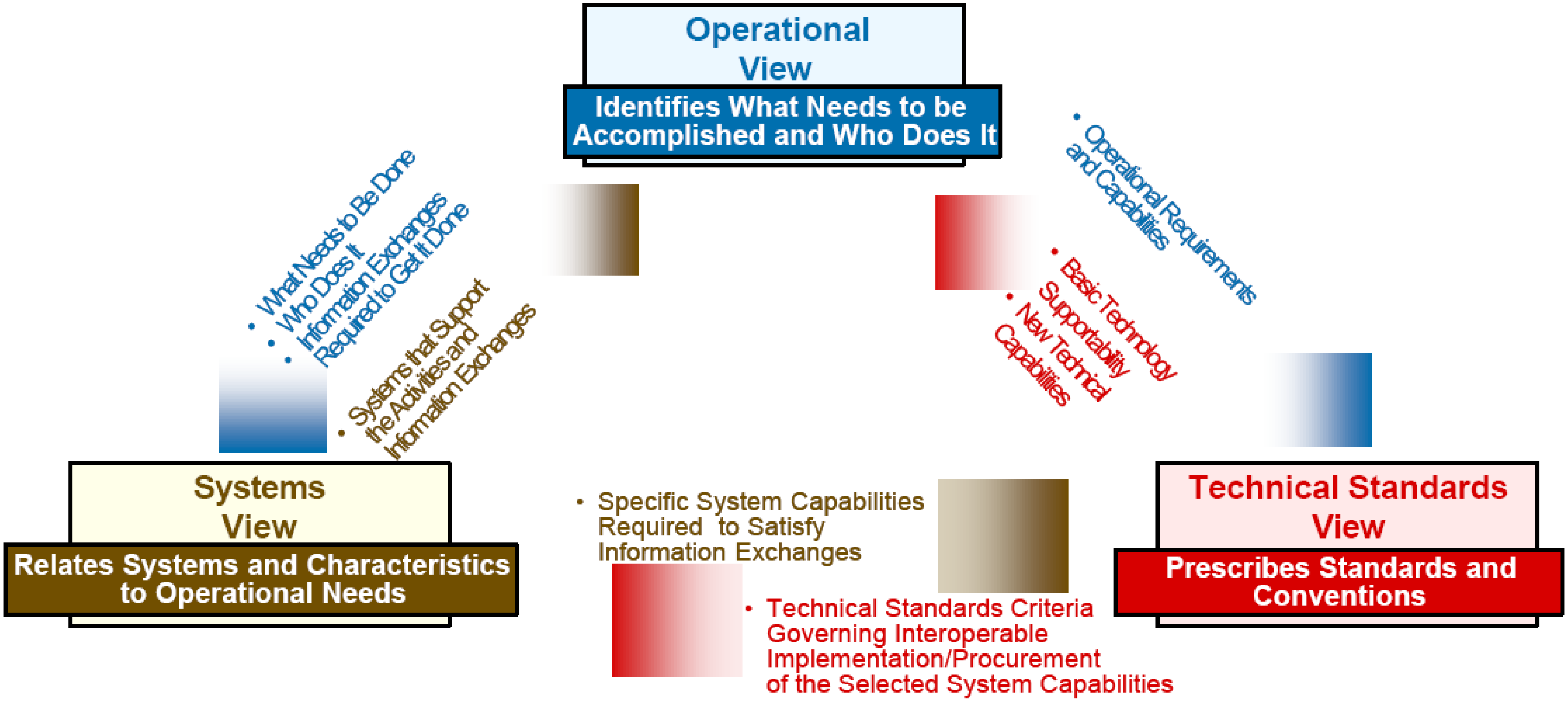
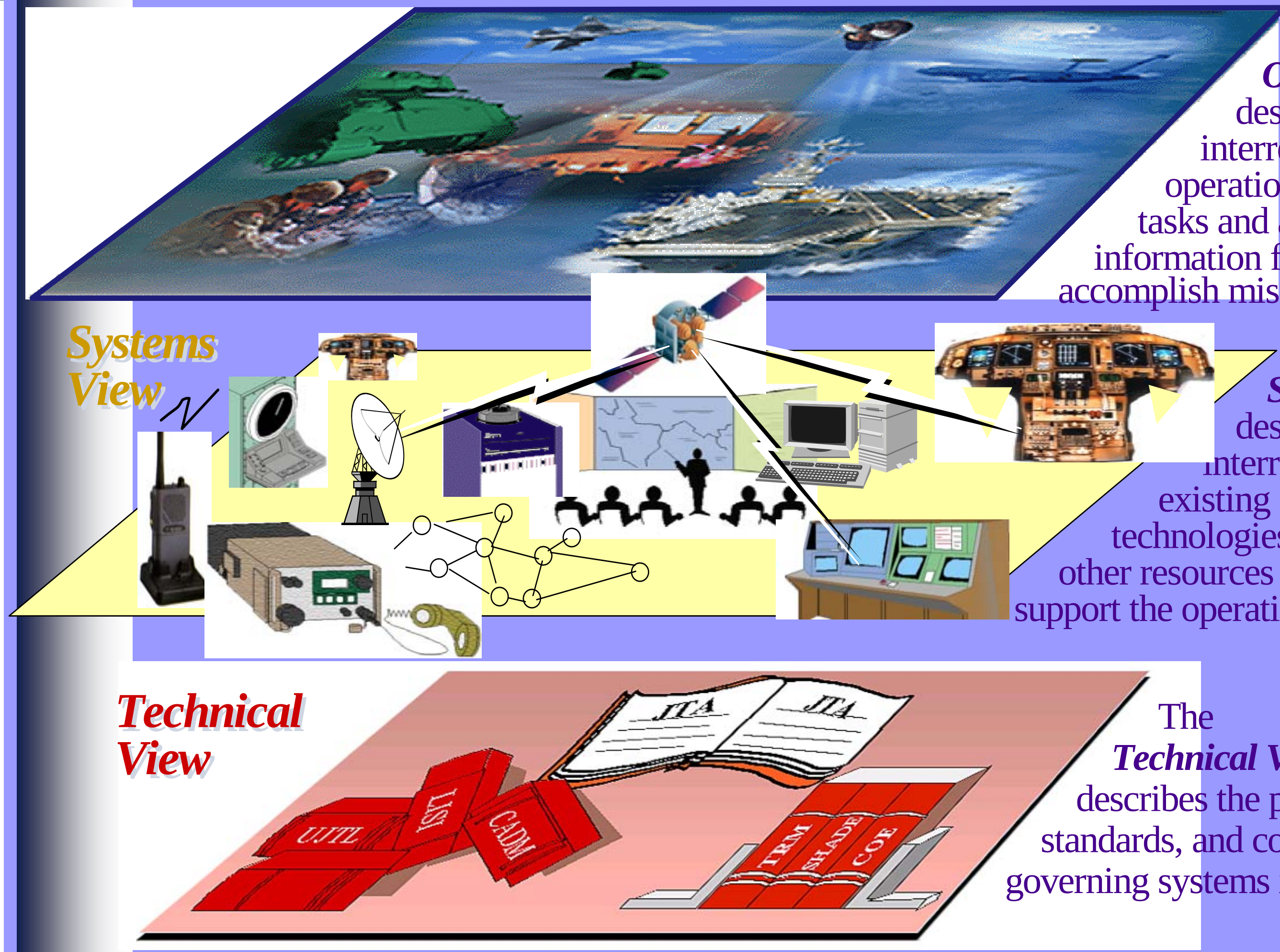


Figure ES-1. Linkages Among Views

DoD Architecture Framework: One Architecture…Three Views



The **_Operational View_** describes and interrelates the operational elements, tasks and activities, and information flows required to accomplish mission operations.

The **_Systems View_** describes and interrelates the existing or postulated technologies, systems, and other resources intended to support the operational requirements.

The **_Technical View_** describes the profile of rules, standards, and conventions governing systems implementation.

Source: DoD AF 1.0 Draft

Analyzing DoDAF Products and Relationships


DoD Architecture Framework
Version 1.5

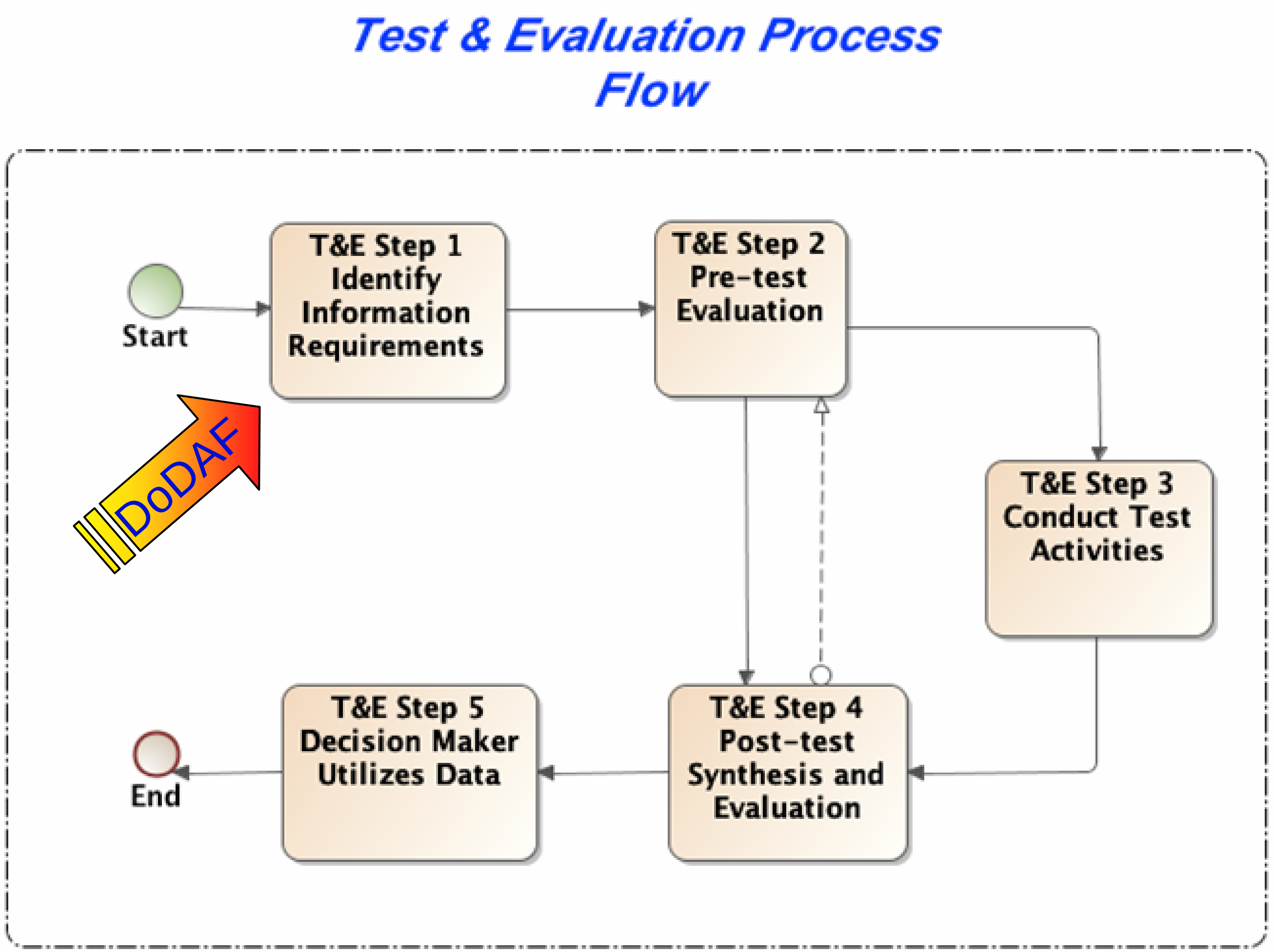
Volume II: Product Descriptions
23 April 2007

2 AVs
9 OVs
16 SVs
2 TVs

Table 2-1: List of Products

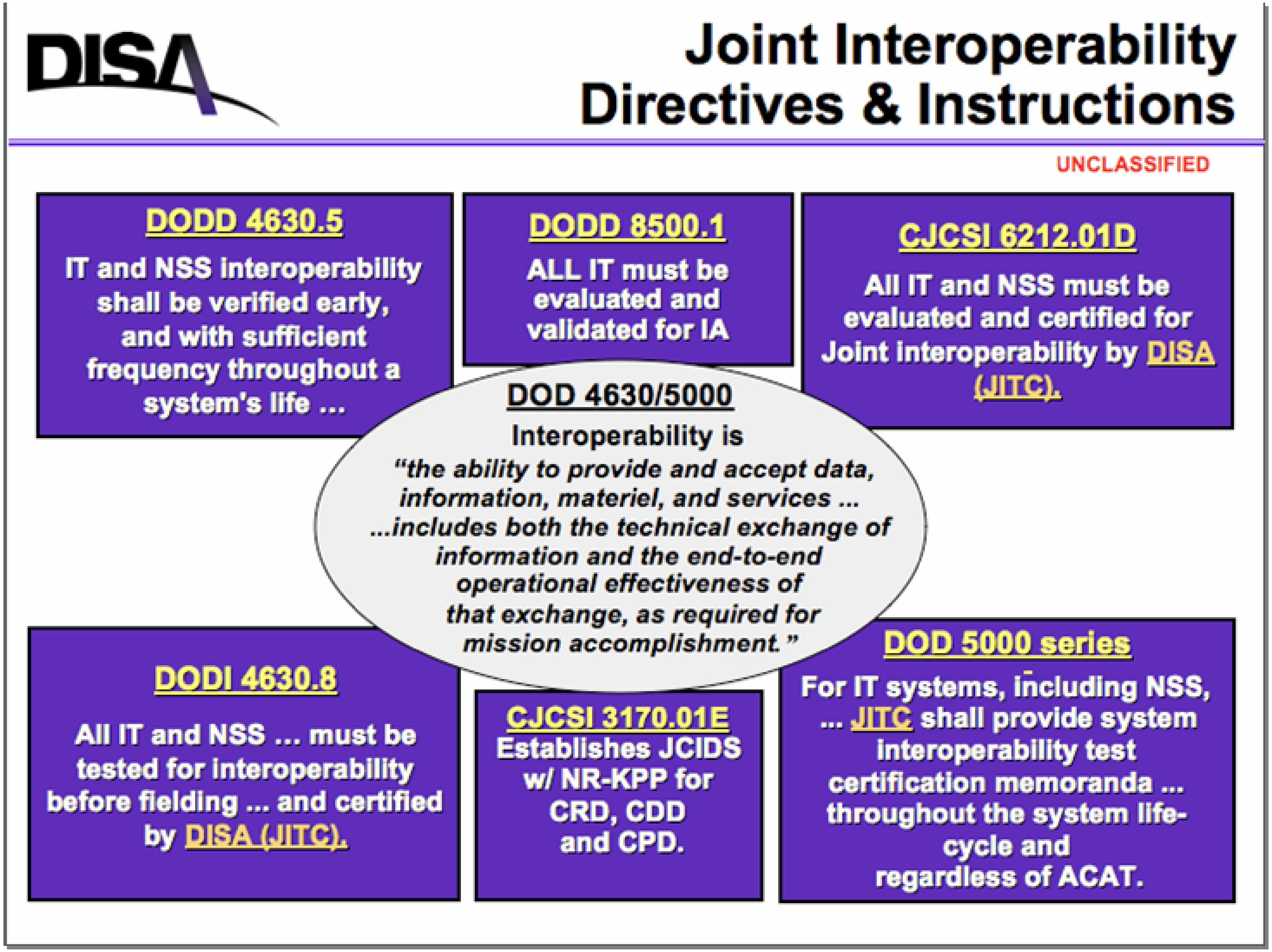
Applicable View	Framework Product	Framework Product Name	Net-Centric Extension	General Description
All View	AV-1	Overview and Summary Information	✓	Scope, purpose, intended users, environment depicted, analytical findings
All View	AV-2	Integrated Dictionary	✓	Architecture data repository with definitions of all terms used in all products
Operational	OV-1	High-Level Operational Concept Graphic	✓	High-level graphical/textual description of operational concept
Operational	OV-2	Operational Node Connectivity Description	✓	Operational nodes, connectivity, and information exchange need lines between nodes
Operational	OV-3	Operational Information Exchange Matrix	✓	Information exchanged between nodes and the relevant attributes of that exchange
Operational	OV-4	Organizational Relationships Chart	✓	Organizational, role, or other relationships among organizations
Operational	OV-5	Operational Activity Model	✓	Capabilities, operational activities, relationships among activities, inputs, and outputs; overlays can show cost, performing nodes, or other pertinent information
Operational	OV-6a	Operational Rules Model	✓	One of three products used to describe operational activity—identifies business rules that constrain operation
Operational	OV-6b	Operational State Transition Description	✓	One of three products used to describe operational activity—identifies business process responses to events
Operational	OV-6c	Operational Event-Trace Description	✓	One of three products used to describe operational activity—traces actions in a scenario or sequence of events
Operational	OV-7	Logical Data Model	✓	Documentation of the system data requirements and structural business process rules of the Operational View
Systems and Services	SV-1	Systems Interface Description Services Interface Description	✓	Identification of systems nodes, systems, system items, services, and service items and their interconnections, within and between nodes
Systems and Services	SV-2	Systems Communications Description Services Communications Description	✓	Systems nodes, systems, system items, services, and service items and their related communications lay-downs
Systems and Services	SV-3	Systems-Systems Matrix Services-Systems Matrix Services-Services Matrix	✓	Relationships among systems and services in a given architecture; can be designed to show relationships of interest, e.g., system-type interfaces, planned vs. existing interfaces, etc.
Systems and Services	SV-4a	Systems Functionality Description		Functions performed by systems and the system data flows among system functions
Systems and Services	SV-4b	Services Functionality Description	✓	Functions performed by services and the service data flow among service functions
Systems and Services	SV-5a	Operational Activity to Systems Function Traceability Matrix		Mapping of system functions back to operational activities
Systems and Services	SV-5b	Operational Activity to Systems Traceability Matrix		Mapping of systems back to capabilities or operational activities
Systems and Services	SV-5c	Operational Activity to Services Traceability Matrix	✓	Mapping of services back to operational activities
Systems and Services	SV-6	Systems Data Exchange Matrix Services Data Exchange Matrix	✓	Provides details of system or service data elements being exchanged between systems or services and the attributes of that exchange
Systems and Services	SV-7	Systems Performance Parameters Matrix Services Performance Parameters Matrix	✓	Performance characteristics of Systems and Services View elements for the appropriate time frame(s)
Systems and Services	SV-8	Systems Evolution Description Services Evolution Description	✓	Planned incremental steps toward migrating a suite of systems or services to a more efficient suite, or toward evolving a current system to a future implementation
Systems and Services	SV-9	Systems Technology Forecast Services Technology Forecast	✓	Emerging technologies and software/hardware products that are expected to be available in a given set of time frames and that will affect future development of the architecture
Systems and Services	SV-10a	Systems Rules Model Services Rules Model	✓	One of three products used to describe system and service functionality—identifies constraints that are imposed on systems/services functionality due to some aspect of systems design or implementation
Systems and Services	SV-10b	Systems State Transition Description Services State Transition Description	✓	One of three products used to describe system and service functionality—identifies responses of a system/service to events
Systems and Services	SV-10c	Systems Event-Trace Description Services Event-Trace Description	✓	One of three products used to describe system or service functionality—identifies system/service-specific refinements of critical sequences of events described in the Operational View
Systems and Services	SV-11	Physical Schema	✓	Physical implementation of the Logical Data Model entities, e.g., message formats, file structures, physical schema
Technical Standards	TV-1	Technical Standards Profile	✓	Listing of standards that apply to Systems and Services View elements in a given architecture
Technical Standards	TV-2	Technical Standards Forecast		Description of emerging standards and potential impact on current Systems and Services View elements, within a set of time frames

When to Start the Process

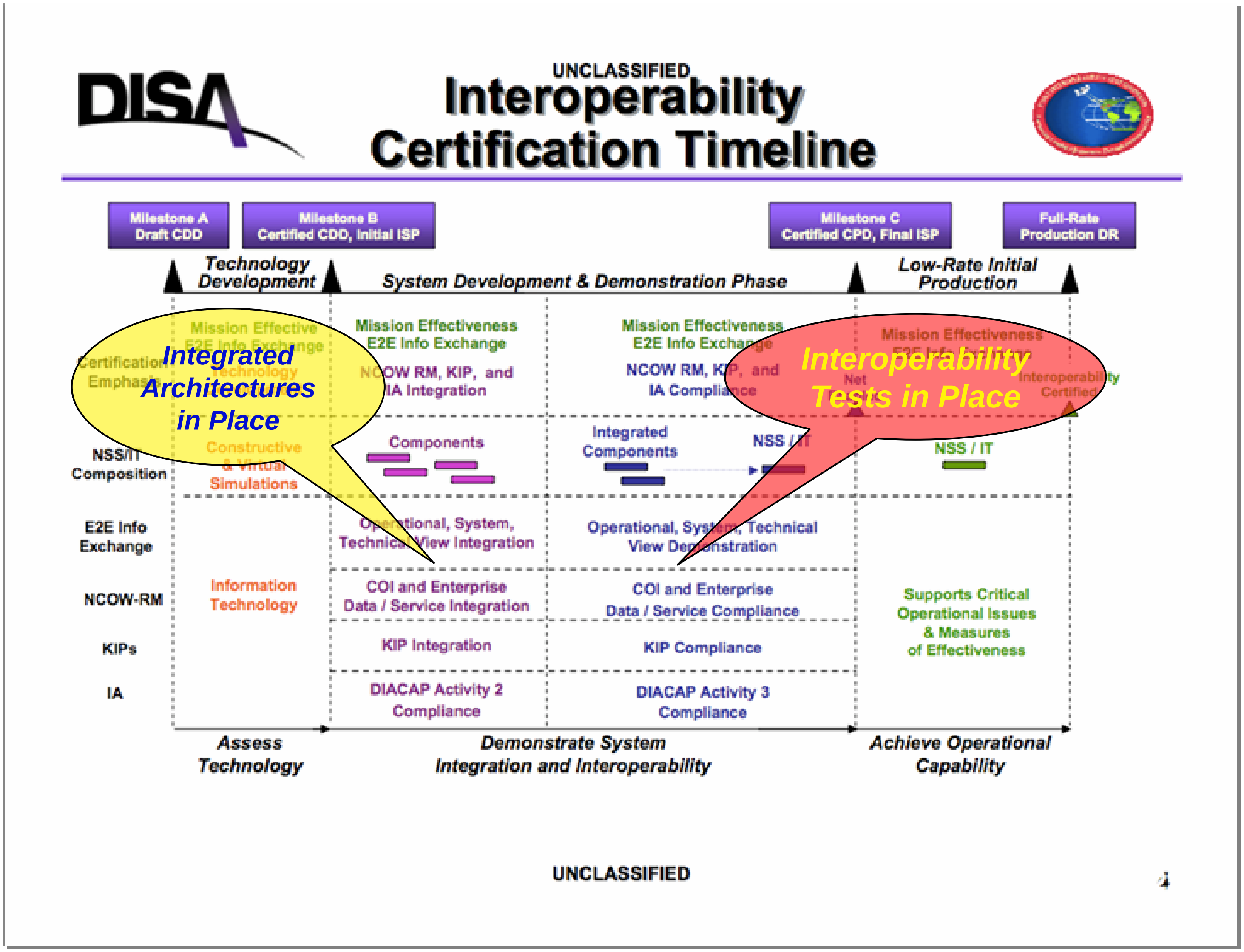


Source: DAU TST 102

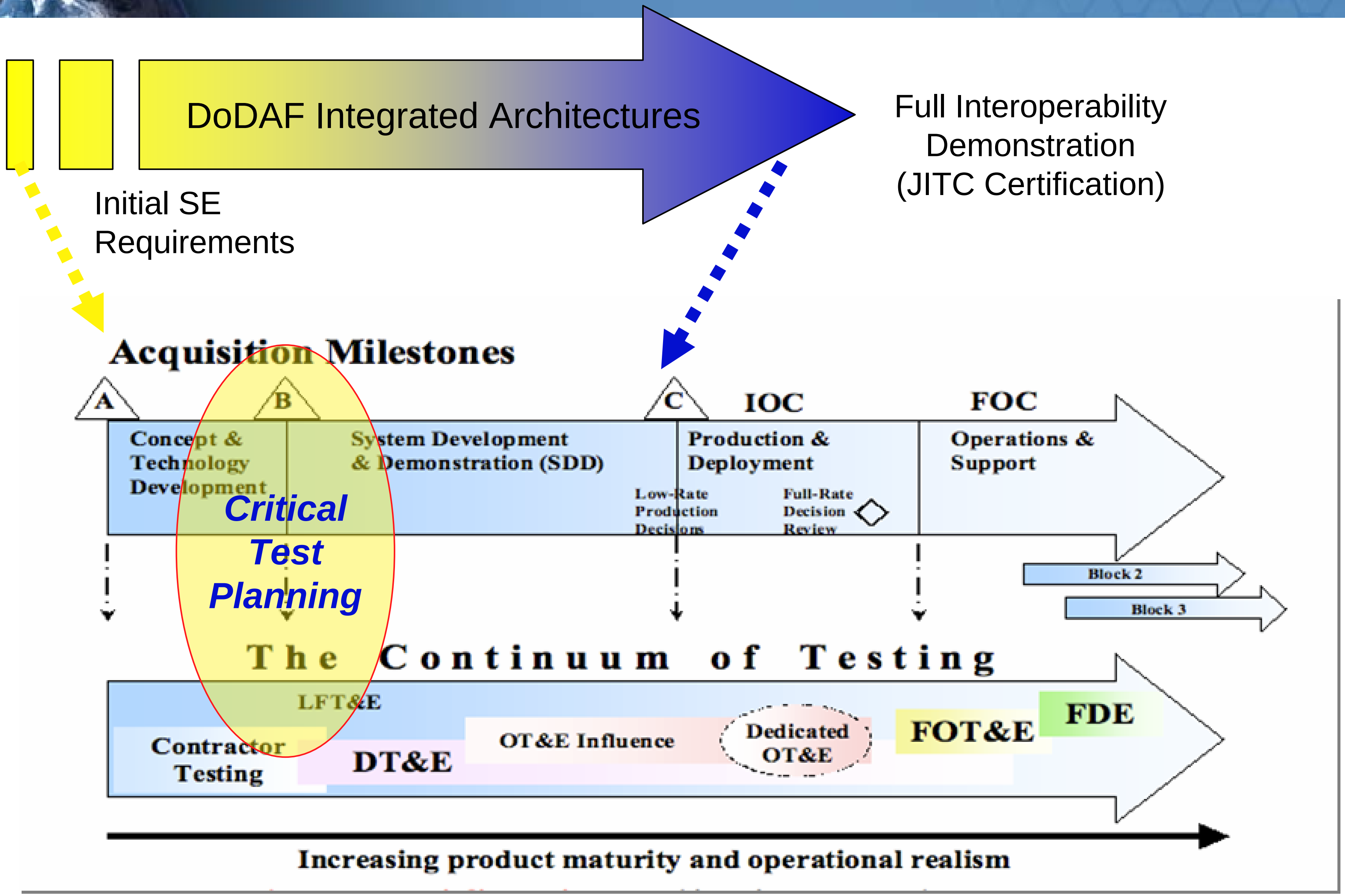
Interoperability Governance



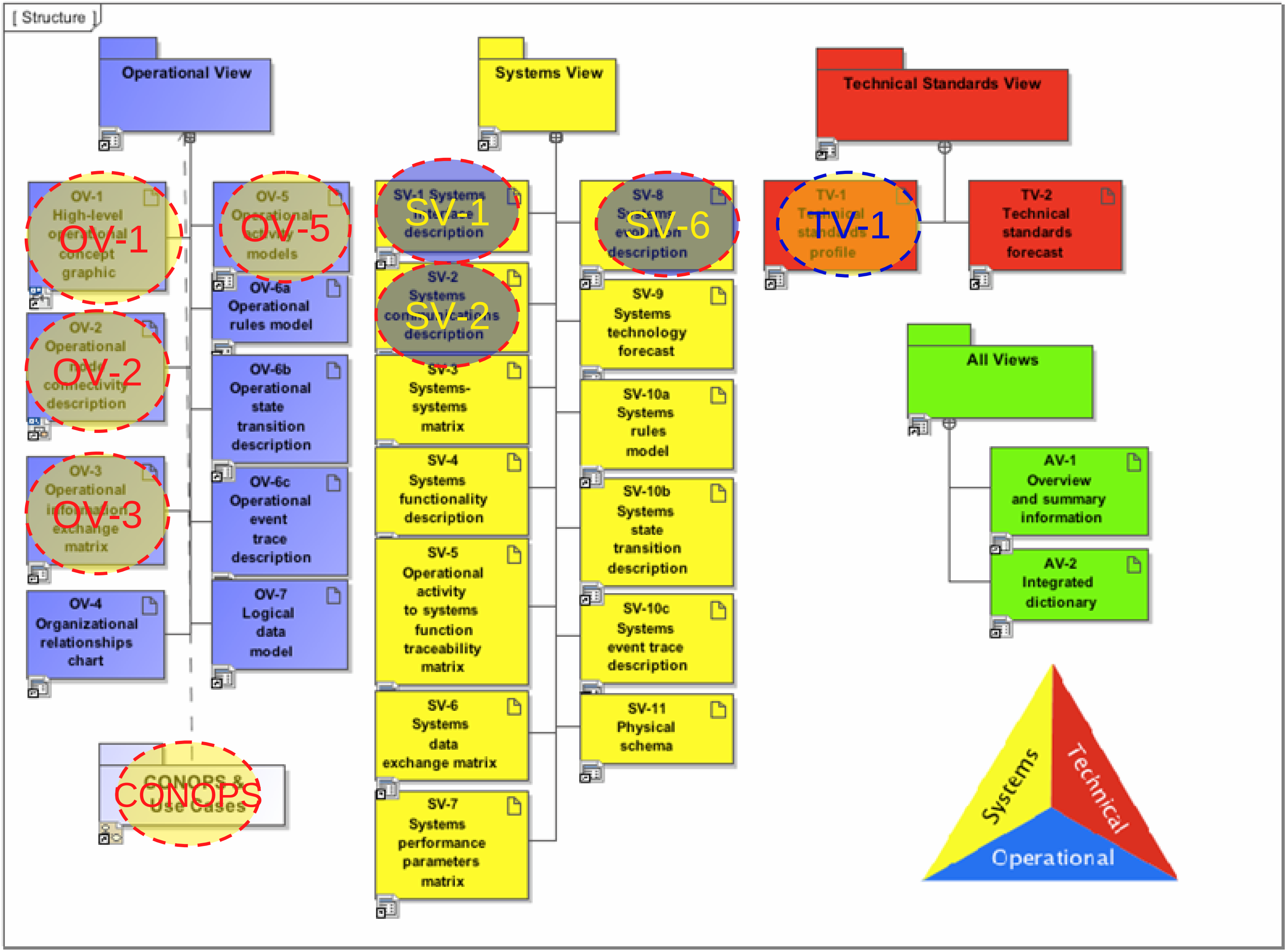
Timeline for Planning



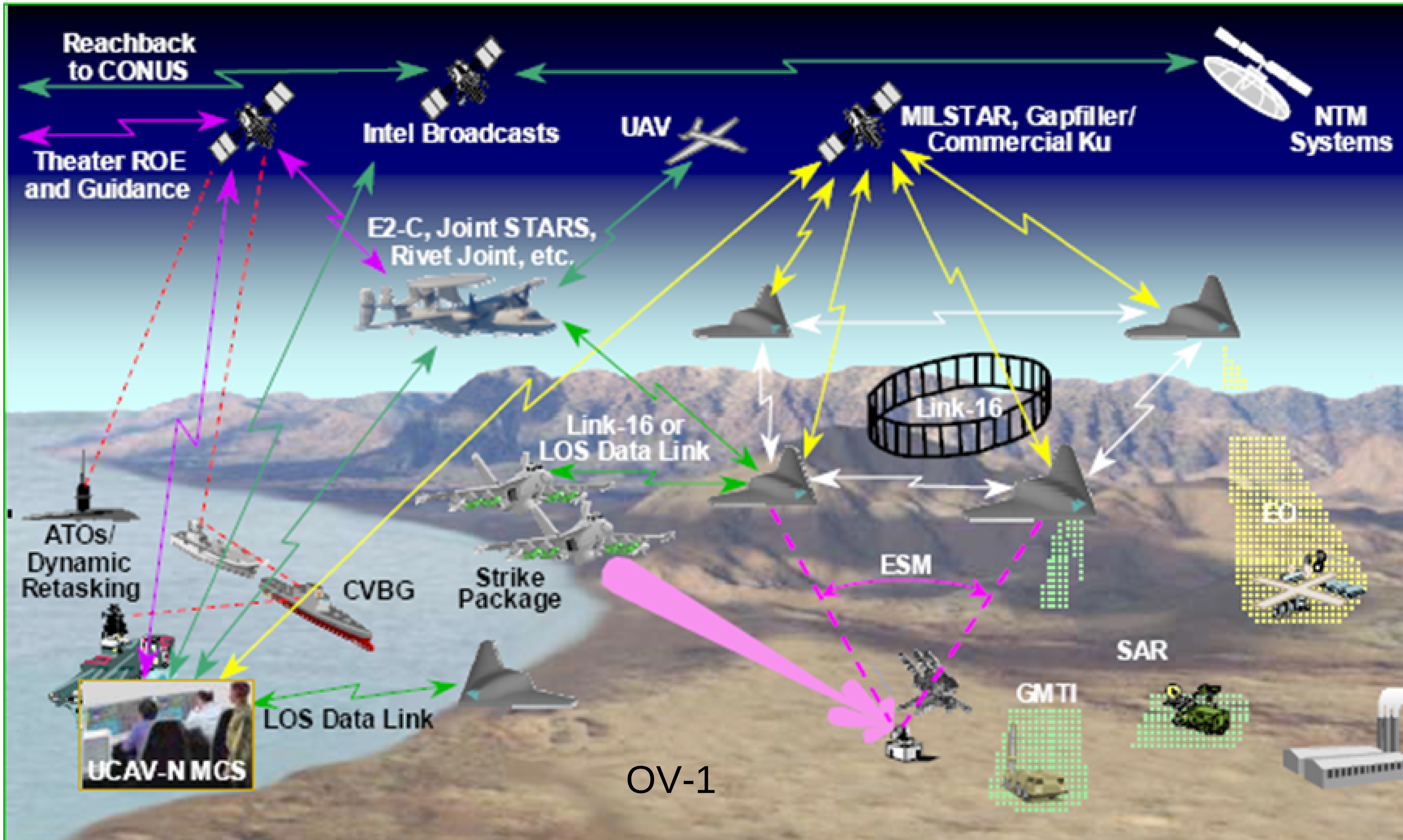
Timing and Interoperability



Critical DoDAF Products for Interoperability Test

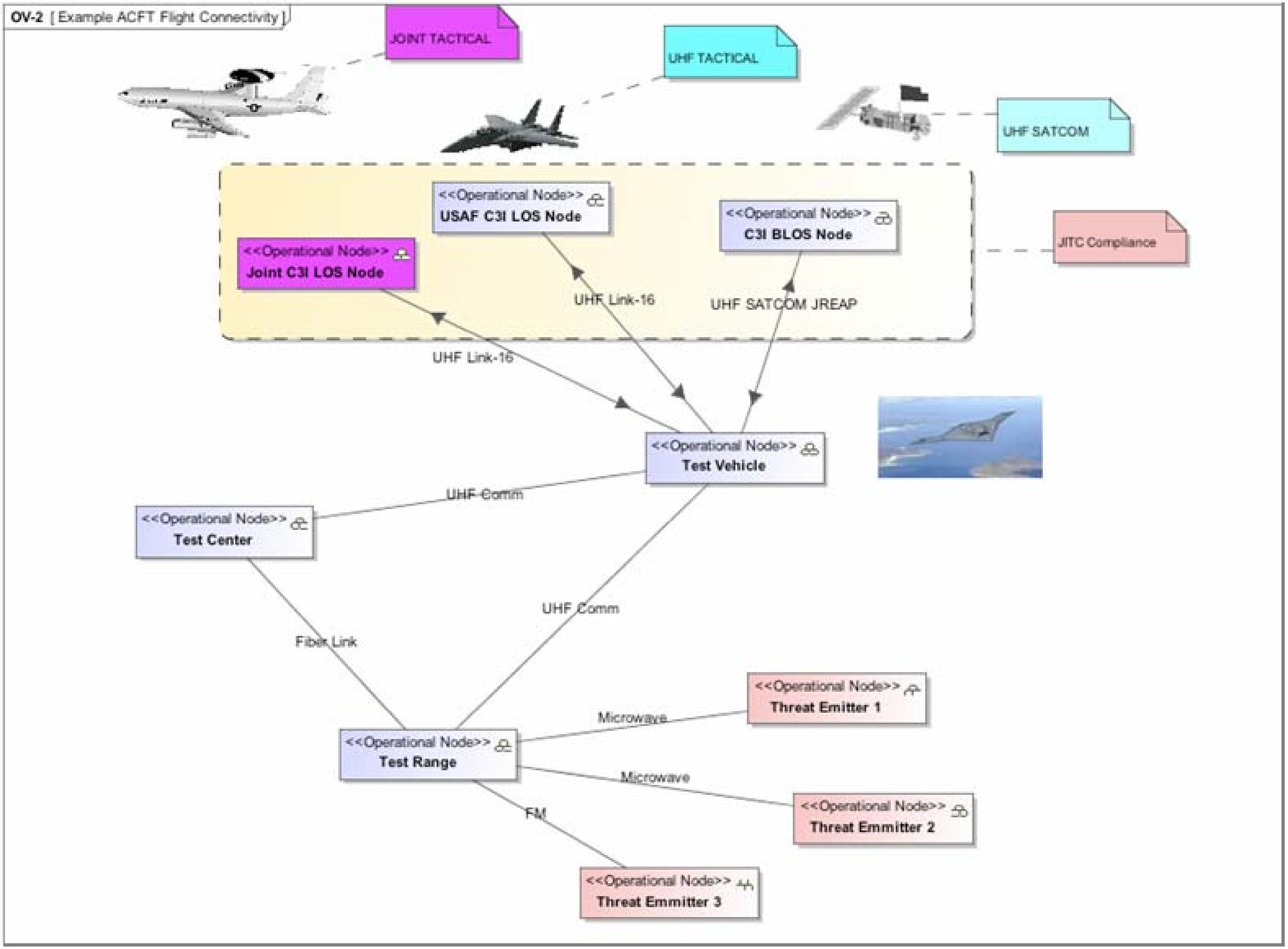


Example OV-1



Source: DARPA J-UCAS 2004

Example OV-2



OV-2 [Example ACFT Flight Connectivity]
JOINT TACTICAL
UHF TACTICAL
UHF SATCOM
JITC Compliance
<<Operational Node>>
USAF C3I LOS Node
<<Operational Node>>
C3I BLOS Node
<<Operational Node>>
Joint C3I LOS Node
UHF Link-16
UHF SATCOM JREAP
UHF Link-16
<<Operational Node>>
Test Vehicle
UHF Comm
<<Operational Node>>
Test Center
UHF Comm
Fiber Link
<<Operational Node>>
Threat Emitter 1
Microwave
<<Operational Node>>
Test Range
Microwave
<<Operational Node>>
Threat Emmitter 2
FM
<<Operational Node>>
Threat Emmitter 3

Important References

- DAU NR-KPPs Web Course (CLM 029)
- DAU Fundamentals of Test & Evaluation Web Course (TST 102)
- DISA / JITC (http://www.disa.mil/index.html) / (http://jitc.fhu.disa.mil/jitc_dri/jitc.html)
- DARS – DoD Architecture Repository System (https://dars1.army.mil/IER/welcome.jsp)

Summary

- Interoperability modifications and upgrades are increasing
- Interoperability is System of Systems Engineering
- Interoperability Testing has special considerations (other nodes and players)
- Can use simulations as well as hardware in the loop. Will require flight demonstrations in a representative environment (JITC Certification)
- DoDAF Architectures are required in all phases of Interoperability Testing (TES - TEMP - Flight Test Plan - JTIC Certification)
- Recommendation - Have a DoDAF Architect on the TRWG (Test Requirements Working Group) early

Motivating Young Americans to Pursue Robotics Technology

With Support From

- University of Maryland Baltimore County
- SURVICE Engineering
- Maryland State Senator Nancy Jacobs
- NJ FTC
- iCNRG FLL
- Silverpop, Inc.
- Creative Kids at Home
- Leavitt's Freight Service
- Home Education Resources
- Pace Academy
- Custom Direct
- Nehemiah Communications
- The Better Hour
- Broadway Appraisals
- Madonna Veterinary Clinic
- Consolidated Printing
- Enktesis, LLC
- Numerous FIRST Teams

Marco Ciavolino
Founding Mentor for TechBrick
Marketing/Communications & Technology Consultant
*enktesis, LLC
Forest Hill, Maryland

Why Would You Be Interested in Teaching Young People Robotics?

Because we need bright, innovative, young engineers to create and maintain our future technologies.

- Good engineers and technologists are raised before they are taught. The penchant for mechanical and conceptual disciplines comes from a lifetime of involvement.
- For the past five years we have coached robotics teams under programs offered by FIRST.

FIRST programs grow engineers and technologists.

Why Are You Hearing About This at NDIA?

The Programs/Products You Support Will Require Young, Smart, Capable Engineers

- We will show a program with more than 200,000 participants world-wide.
- We will show you a program that doubles or triples a student’s interest in science and technology.
- We will show you a program that will bring to your future projects the talent you need.
- Some NDIA divisions are already working with FIRST, we need the rest of you to consider involvement.

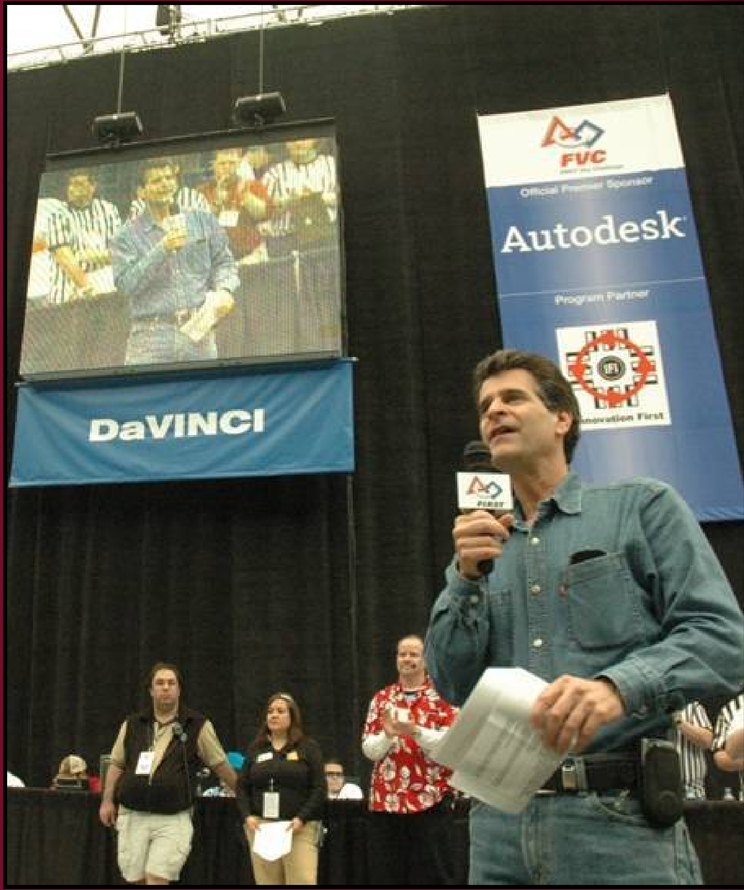
The programs are offered through US FIRST… What is US FIRST?

Marco Ciavolino * Marco@TechBrick.com * www.TechBrick.com * www.USFirst.org

What is US FIRST?

Founded by Dean Kamen

- *FIRST* was founded in 1989.
- To inspire young people's interest and participation in science and technology.
- Provides accessible, innovative programs that motivate young people to pursue education and career opportunities in science, technology, engineering, and math, while building self-confidence, knowledge, and life skills.



For
Inspiration and
Recognition of
Science and
Technology

This is without a doubt one of the most engaging and challenging programs available.

Who is Involved?

Global Participation 2007

- 156,000 Students
- 12,000 Robots
- 44,000 Mentors
- 28,000 Event volunteers
- 39 Countries
- 1000's of Corporate Sponsors

Millions of lessons learned…

What are the Programs?

JFLL JR. FIRST LEGO® League	FLL FIRST LEGO® League	FTC FIRST Tech Challenge	FRC FIRST Robotics Competition
For ages 5-8	Ages 7-15	Jr. High – HS	High School
Uses the annual theme for project-based work.	Uses annual themes to engage young students in applied research.	Uses a mechanical challenge combined with real-world teamwork and cooperative efforts.	
Based on standard science project materials	Based on LEGO Mindstorms NXT or RCX Robotics Systems.	Based on an advanced robotics system.	
Up to 6	Up to 10	Up to 10	As many as needed.

What are the Programs?

JFLL: Junior FIRST LEGO League

- Based on LEGO Education Kits.
- 2-6 Students.
- Thematic Challenges.

JFLL
JR. FIRST LEGO® League

What are the Programs?

FLL: FIRST LEGO League

- Based on LEGO Mindstorms NXT or RCX Robotics Systems.
- 4-10 Students.
- Thematic Challenges: 4 Parts.

FLL
FIRST LEGO® League

power puzzle
Nano Quest
Ocean Odyssey
No limits
Mission Mars
CitySights!
Arctic Impact
Volcanic Panic!
First Contact

What are the Programs?

FTC: FIRST Tech Challenge

- Based on advanced robotics systems.
- 2-10 Students.
- Uses a mechanical challenge combined with real-world teamwork and cooperative efforts.

FTC
FIRST Tech Challenge

QUAD QUANDARY

Hangin'-A-Round

Marco Ciavolino * Marco@TechBrick.com * www.TechBrick.com * www.USFirst.org

What are the Programs?

FRC: FIRST Robotics Competition

- Based on advanced robotics system.
- 10-60 Students.
- Uses a mechanical challenge combined with real-world teamwork and cooperative efforts with mentors and sponsors.

FRC
FIRST Robotics Competition

What are the Programs?

International Competition

- 10,000 students
- 6000 mentors
- 1000's of volunteers
- 3 Programs
  - ✓ FLL, FTC, FRC

What are the Results of This Work?

The Numbers

- Steady Growth and Involvement

JFLL JR. FIRST LEGO® League	FLL FIRST LEGO® League	FTC FIRST Tech Challenge	FRC FIRST Robotics Competition
3 Years	10 Years	4 Years	14 Years
1000 Teams	10,000 Teams	1200 Teams	1400 Teams

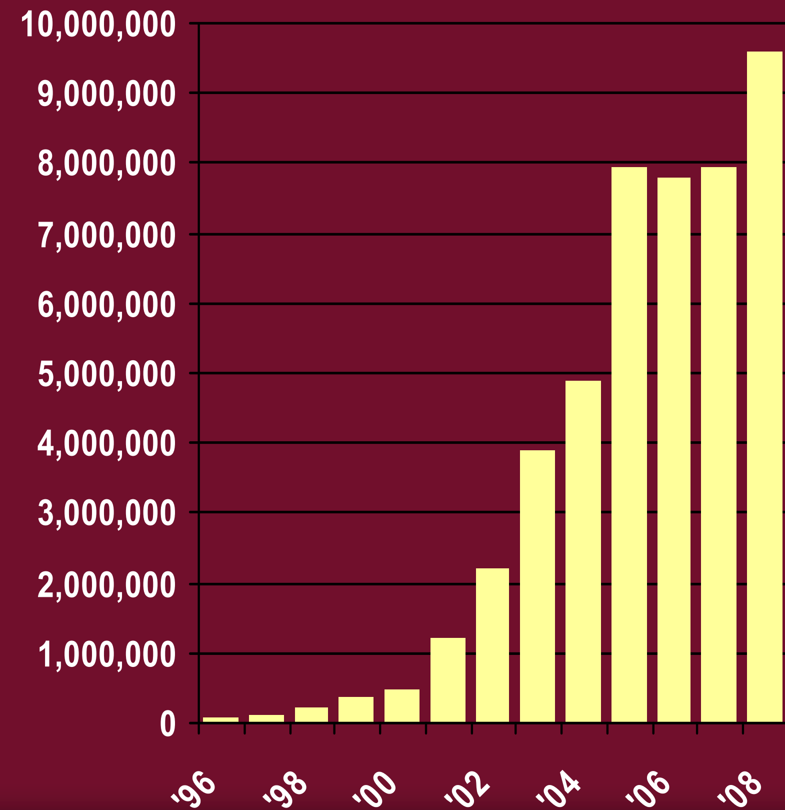
What are the Results of This Work?

Colleges: More than 100 Colleges Offer Scholarships

Colorado State University-Pueblo
Arizona State University
ASME
Boston University
Clarkson University
Cleveland Institute of Art
College for Creative Studies
Colorado Technical University-Denver
Daniel Webster College
DeVry University
Drexel University
Eastern Michigan University
Embry-Riddle Aeronautical University
Fairleigh Dickinson University
Ferris State University
Florida Atlantic University
Florida Institute of Technology
Georgia Institute of Technology
Grand Valley State University
Hampshire College
Henry Ford Community College
Hofstra University
Idaho State University
Illinois Institute of Technology
ITT Technical Institute (combined)
Kansas State University
Lake Superior State University
Lawrence Technological University
Marquette University
Massachusetts Institute of Technology
Mercedes-Benz USA LLC
Michigan State University
Michigan Technological University
New Hampshire Technical Institute
New Jersey Institute of Technology
Northeastern University
Ohio State University
Olin College of Engineering
Oregon State University
Pennsylvania College of Technology
Phil Clancy Scholarship
Polytechnic University
Purdue University/Delphi Corporation
Raytheon Company
Rensselaer Polytechnic Institute
Rochester Institute of Technology
Schoolcraft College
Society of Women Engineers
Southern California Regional Robotics Forum
Spring Arbor University
Temple University
University of Arkansas-Little Rock
University of California-Davis
University of Central Florida
University of Delaware
University of Denver
University of Hartford
University of Illinois-Chicago
University of Kansas
University of Massachusetts Lowell
University of Michigan/Delphi
University of Minnesota
University of Missouri-Kansas City
University of Nebraska-Lincoln
University of New Hampshire
University of Rochester
University of South Carolina
University of Southern California
University of Toronto
University of Waterloo
Virginia Commonwealth University
Washington State University
Washtenaw Community College
Wayne State University
Wisconsin Lutheran College
Worcester Polytechnic Institute
Kettering University

What are the Results of This Work?

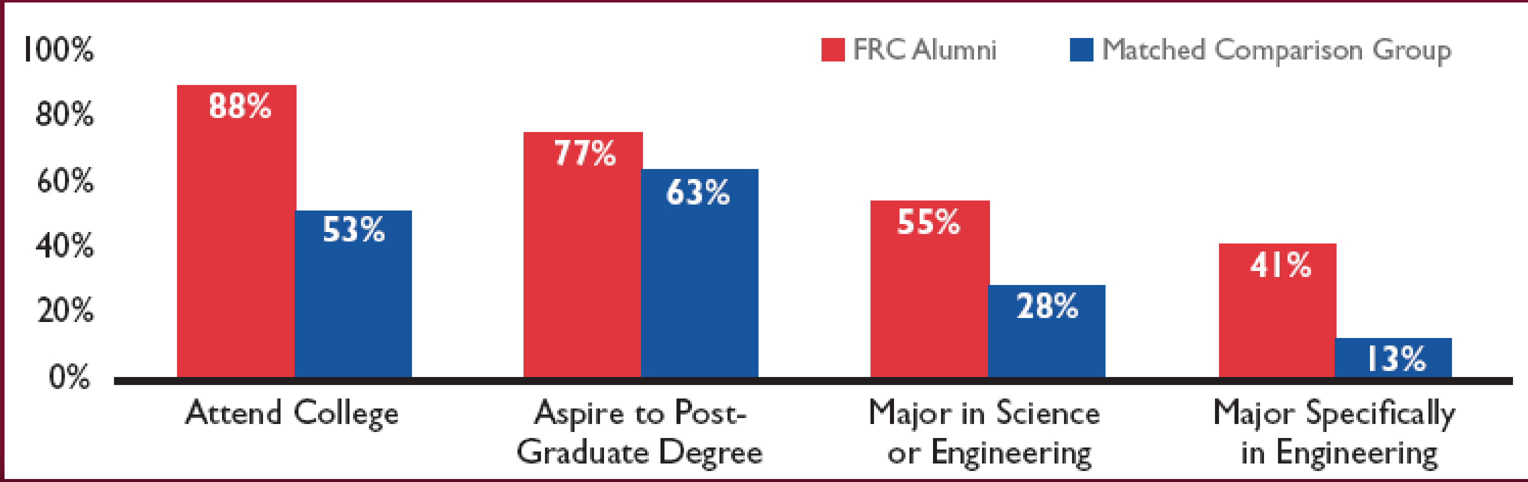
Over $9.5 million in scholarship funds available to *FIRST* participants



What are the Results of This Work For Our Nation?

The Alumni

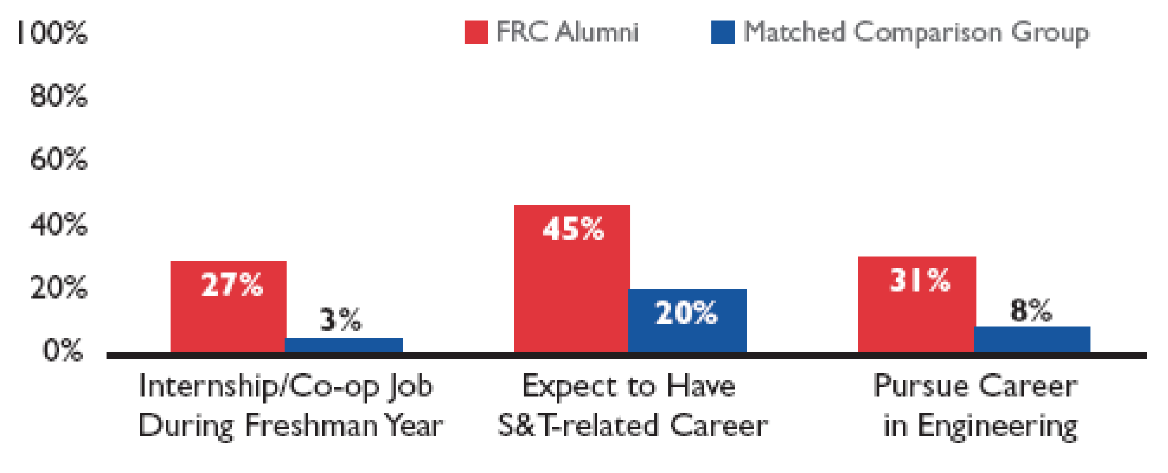
- *FIRST* Students vs. Comparison Group:
  - ✓ Seek Education in Science & Technology.
  - ✓ Twice as likely to major in science or engineering.
  - ✓ More than three times as likely to major specifically in engineering.



What are the Results of This Work For Our Nation?

The Alumni

- Earn Career Opportunities:
  - ✓ Almost ten times more likely to have an internship.
- Expect to Pursue Science & Technology Careers:
  - ✓ More than twice as likely to pursue S&T career .
  - ✓ Nearly four times as likely to pursue career specifically in engineering.



Real-World Results: TechBrick Robotics

Our History

- TechBrick was formed 2004
- First competition in 2005
- Growth from 20-120 members
- Monthly activities
- 30 team participants in 2007-08
  - ✓ JFLL, FLL, & FTC
- Interest continues to grow
- Organized Maryland JFLL Tournament
- Regional seminars on starting a team
- First high school judges for FLL

Real-World Results: TechBrick Robotics

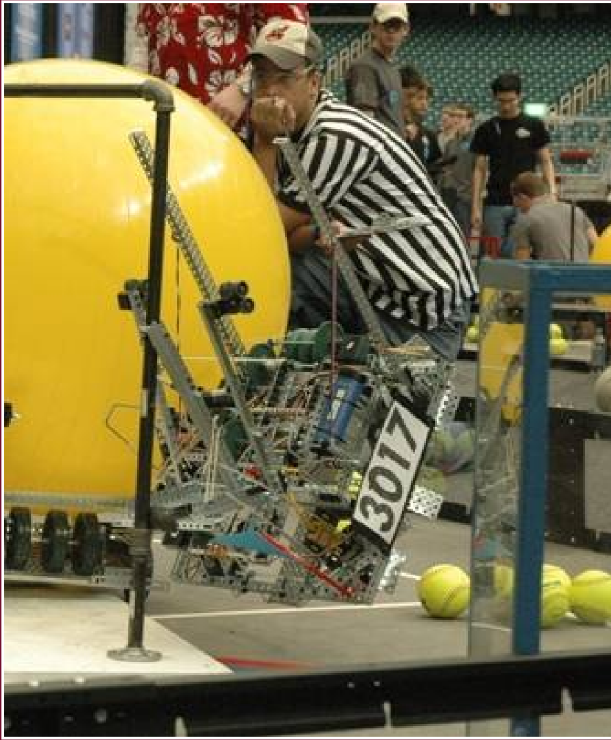
Monthly Meetings

- More that 120 children registered
- Builds interest for teams
- Creative exercises
  - ✓ Animation
  - ✓ Documentation Tasks
  - ✓ Boat building
  - ✓ Bridge Building
  - ✓ Guest Speakers

Real-World Results: TechBrick Robotics

Competition Teams: Innovative Solutions

- Light Sensor: Improved by 1200% (FLL)
  - ✓ Using a ‘Spider Man Magnifying Glass’
- Sideways Stepping Bot (FLL)
  - ✓ Drive forward, step right and left
- Torque/RPM Discoveries (FLL)
  - ✓ Design to specifications exercise
- Ball and Bar Lifting Bot (FTC)
  - ✓ Capture the primary object
- Ring Lifting Automation Device (FTC)
  - ✓ Pickup rings with materials handling device



Real-World Results: TechBrick

State Competitions

- UMBC (University of Maryland, Baltimore County)
- TCNJ (The College of New Jersey)
- UD (University of DE)
- CSM (College of Southern Maryland)

Real-World Results: TechBrick Robotics

Award Winning Results

Team Spirit

Innovate Awards

Amaze Award

Marco Ciavolino * Marco@TechBrick.com * www.TechBrick.com * www.USFirst.org

Real-World Results: TechBrick Robotics

A Robust Website with Useful Resources

- Team Tips
- Worksheets
- Projects for group work
- Photos and guidelines
- Global traffic

Real-World Results: TechBrick Robotics

LEAP
Science is Fun!
LEARN EXPLORE AND PLAY

Community Service

Library Programs

Local Presentations to Sponsors

SURVICE Engineering Corporation

Real-World Results: TechBrick Robotics

Media and Fun

Adopted Team Members


THE AEGIS FRIDAY, MARCH 30, 2007 www.theaegis.com

Robotics team heads for international competition

Five Harford home-schoolers build bots

'It's so cool what they do'
—MARCO CIAVOLINO

Featured in Media

Real-World Results: TechBrick Robotics

Focused Children: Good for America…

- Of the 50+ children on teams over the past five years at least half have been encouraged to pursue math, science, and engineering studies.
- Numerous innovations in research, design, and execution.
- Lessons learned in…
  - ✓ Project Management
  - ✓ Processes
  - ✓ Teamwork
  - ✓ Implementation
  - ✓ Competition
  - ✓ Design
  - ✓ Research

Marco Ciavolino * Marco@TechBrick.com * www.TechBrick.com * www.USFirst.org

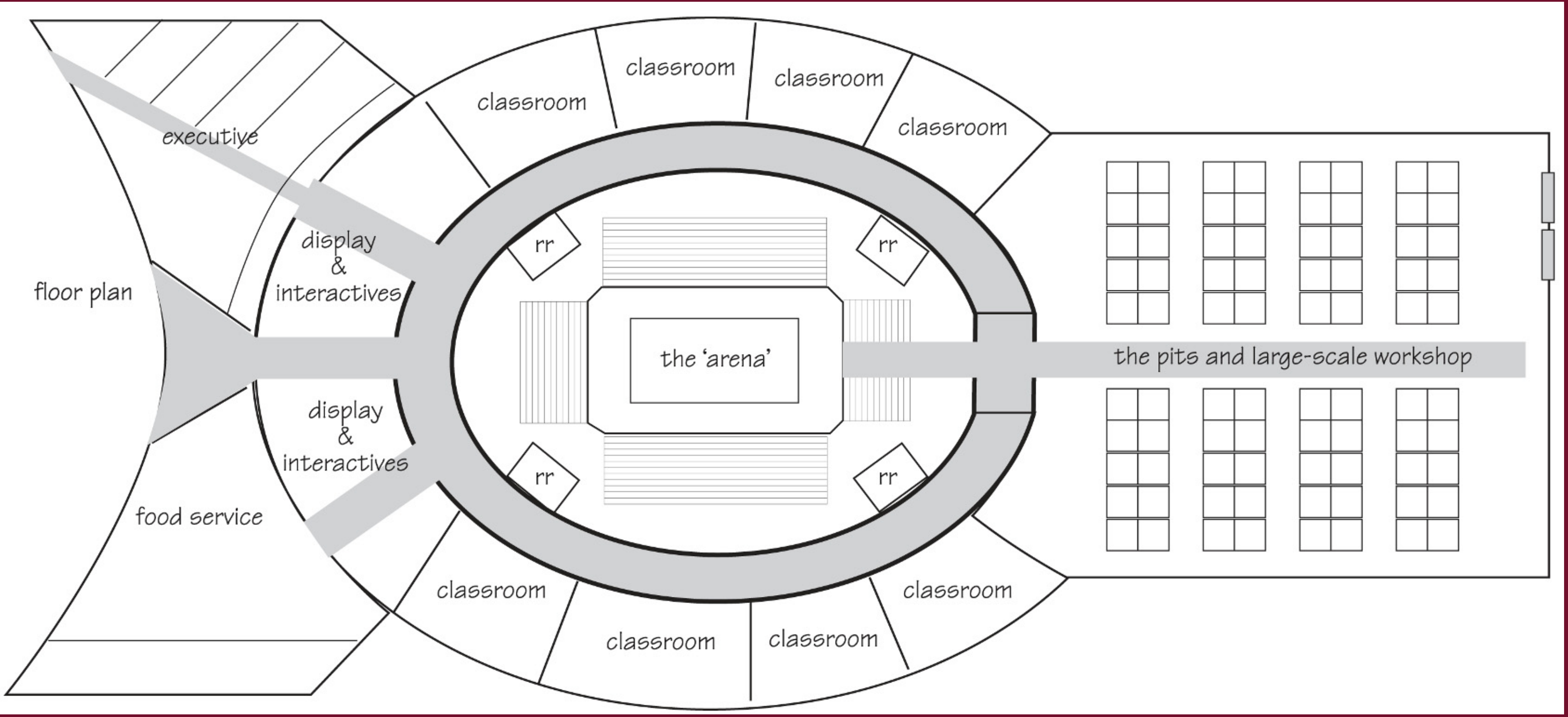
Real World Results: Around The World

Our Experiences Have Been Repeated Around the World

- Thousands of schools and organizations have done exactly the same work.
- Young engineers are now in the workplace or on their way to productive, effective careers.

TechBrick Robotics: Our Dream

A Regional Robotics Center



TechBrick Robotics: Our Dream

The First National Robotics Center

- A multi-use facility
  - ✓ Ongoing classes
  - ✓ Regional and national robotics competitions
  - ✓ Technology tradeshows
  - ✓ Technology meetings and conferences
  - ✓ Parties and events (themed)
  - ✓ Educator training (CEU)
  - ✓ College Internships
  - ✓ Outdoor space for large vehicles and displays
    - ✓ Robotics ‘mini-proving grounds’

How Can You Help?

These Are Some Of The Attending Companies That Are Already Involved Nationally With FIRST…

- BAE Systems
- The Boeing Company
- Air Force Operational Test and Evaluation Center
- Northrop Grumman Corporation
- General Dynamics Corporation
- Lockheed Martin
- Naval Air Warfare Center Weapons Division
- Aberdeen Test Center
- Edwards Air Force Base
- GA Tech Research Institut
- Honeywell International, Inc.
- Lockheed Martin
- Raytheon Company
- US Army
- USAF

Let's Take a Look at The Benefits of Getting Involved…

How Can You Help?

Consider the Opportunities

- Supply equipment/parts.
- Offer scholarships.
- Provide facilities for teams and events.
- Assign mentors, volunteers, consultants.
- Create internship opportunities.
- Financial support.

How Can You Help?

Consider the Benefits To You and To Our Nation

- Strengthens public relations and community relations.
- Builds national technological literacy.
- Creates an incubator for interns and future employees.
- Motivates volunteer opportunities for employees.
- Applied professional development for employees.

How Can You Help?

Find a US FIRST team in your region and get involved:

- Visit the US FIRST website at www.USFIRST.org to get a full understanding of the program.
- Be a champion for participation within your company or association.
- Start a FIRST program in your child's school.
- If you're from the Aberdeen/Edgewood Area
  - ✓ Consider assisting TechBrick with a corporate sponsorship. Visit www.techbrick.com/support for more information.

Who to Contact…

- Contact Marco Ciavolino for information about The National Robotics Center or TechBrick (marco@techbrick.com, 410-838-8264)

- For information about involvement in FIRST nationally, contact Cindy Randall for information. (crandall@usfirst.org, 603-666-3906 x403)

A Simple Way to Assist Today…

The *iRobot Roomba* is clearly the first successful home robot.

Stop by our booth for a chance to win a Roomba...

Keep your home or office *'Roomba'* clean…

Make a suggested contribution for one or more tickets. Join us at the awards luncheon on Wednesday for the drawing.

Our thanks to iRobot for providing the Roomba

Warfare Systems Engineering Challenges and Test and Evaluation Approaches

Presented to:

24th Annual National Test & Evaluation Conference Palm Springs, CA February 25-28, 2008

Presented by:

Rob Connerney, Deputy NAVSEA Warfare Center T&E Executive
401 832-2151
connerneyra@npt.nuwc.navy.mil

Outline of Presentation:

DoN T&E Challenges & Strategies
NAVSEA Core T&E Functions
NAVSEA T&E Initiatives
(Integration, Interoperability, M&S, Undersea Tracking Ranges and T&E capabilities, Human Capital Strategy)

Naval T&E Challenges: Improving the T&E Process

Challenges

•The growing need for the large scale joint and dynamic test environment of the future, e.g. Net Centric Warfare, FoS/S, coalition operations.

• The increasing technological complexity and tightly integrated interoperability across weapons systems.

• Current information and accounting systems do not provide adequate visibility of T&E events and costs to maintain and improve process and capability.

Strategies

• The Joint Capability Integration Development Requirement and the budget process needs to be better synchronized to reduce unanticipated cost changes.

• The use of combined Integrated DT/OT is one of the successful "innovative" T&E approaches by Navy program managers to cut testing costs.

• Increased use of M&S can reduce Acquisition programs costs and improve the value of DT and OT data.

• The return of M&S across programs can be enhanced through investments in common infrastructure, policies, and standards and reuse.

Navy T&E Initiatives

Navy T&E Board of Directors

- Established by DASN/RDA
- RADM Landay (co-chair) and COTF (co-chair), OPNAV N091 (Exec Sec), PEOs, N1, N4, N6, N8, SYSCOMs, MCOTEA and CFFC
- Strategic Priorities
  - Establish governance
  - Inventory the domain
  - Define metrics
  - Create value by optimizing resource utilization

- N43 Range Contribution to Readiness Effort
- PEO T&E Forum
  - Coordinates T&E actions across PEOs
  - Identify opportunities for efficiencies
- PEO Ships T&E Working Group
- NAVSEA Warfare Center T&E Working Group
  - Representatives from each WC division
  - Forum for:
    - WC leadership in joint initiatives
    - Knowledge sharing, synergy/efficiency initiatives
    - Recommendations for T&E policy formulation
    - Coordination of NAVSEA T&E action items

Renewed focus and attention on T&E

DoN Integrated Testing Strategies

- FY07 Nat'l Defense Authorization Act, Sect 231. directed USD and DOT&E to review DOD policies and practices on T&E.

- Integrated testing major theme
  - Goal: early detection & correction of program deficiencies

- Navy Proposed Draft DoD IT definition: Integrated testing is the collaborative planning and collaborative execution of test phases and events to provide data in support of independent analysis, evaluation and reporting by all stakeholders (government, contractor, operational test communities).

- PM identifies program as "Integrated Test" program
- Establishes a test team to collaboratively create and manage the TEMP
- Identify test parameters, data, and resources required for development of DT/ OT test plans, and certifications, to optimize test data collection while minimizing test resource required.

- MDA provide formal direction establishing the Test Team in the program's first ADM

- Contractor full participation in the IT planning and execution included in RFP and contract.

NAVSEA T&E Initiatives In Support of DoN Directives

- **Implement Integrated T&E Strategies**
  - Combined DT/OT
  - Synergy DT/OT with Fleet Training Events
- **Implement Interoperability T&E**
  - Distributed Engineering Plant
  - Joint T&E Distributed Engineering Plant
  - Coalition T&E
  - Integral Fire 07
- **Promote Consolidated T&E Capability**
  - Undersea Tracking Range Collaboration and Roadmap Development
  - Synthetic Environments to Enhance ASW Operational Effectiveness
  - Test Assets & M&S
  - T&E Human Capital Strategy
- **Establish Strategies for Transformational T&E**
  - Establish Rapid Response CREW T&E
  - Establish M&S Accreditation Process
  - Establish Open Architecture T&E

Combined DT/OT Initiatives: NAVSEA Supporting CFFC SEA TRIAL

Virtual SYSCOM Sea Trial Collaboration Team

- *NAVSEA, NAVAIR, and SPAWAR, with support from NWDC*
- *Share knowledge of the SYSCOMs' Experimentation processes, tools and venues*

3rd Fleet conducted a Sea Trial Symposium for Sea Shield Experimentation

- Identified Fleet Warfighting gaps
- Aligned and prioritized experimentation documented in STIMS
- Use experimentation to fix the short term gaps
- Provide representation to the STESG

NAVSEA develops initiatives to rapidly solve gaps and cost

- Provide Engineering review of initiatives and gaps
- Provide operation & system architecture views

PEO PM's provide DT & OT event activity to NWDC

NWDC vet experiments through SYSCOM's prior to Fleet Collaborative Team action*

- Support Sea Trial Information Management System (STIMS)

Sea Strike - 2nd fleet - NAVAIR
Sea Shield - 3rd Fleet - NAVSEA
Forcenet - NETWARCOM - SPAWAR
Sea Base - 2nd Fleet - NAVAIR

Distributed Engineering Plant Overview (NSWCDD)

- **The Distributed Engineering Plant (DEP)**
  - Critical element of the Navy's response to Battle Force Interoperability
  - Formed by Federating Combat System Sites Dispersed Around the United States
  - HITL CS suite to evaluate how systems interact with CEC and TADIL environments
  - All ship baselines require DEP evaluations prior to deployment
  - A High-Fidelity, Shore-Based distributed Force Test bed
  - Demonstrated utility for Industry participation
  - Demonstrated utility for industry particiapation
  - Established foundation for and compatible with JDEP
- **Primary mission to provide Shore-based Force-level testing of deploying CSGs/ESGs.**
  - Force Interoperability Assessment
- **The mission has evolved to support the entire acquisition cycle.**
  - Force-Level Performance
  - Prototype Evaluation
  - Developmental Systems
  - Force Problem Resolution

DEP Goal is to Enable Navy Acquisition Decisions Based on Sound Force System Engineering

NAVSEA
NAVAL SEA SYSTEMS COMMAND
SEA 05
Naval Systems Engineering Directorate

Navy Joint and Coalition Interoperability Challenge

Distributed Engineering Vision

Coalition

Joint

Navy

Coalition Distributed Testing (2007)
8 MTMD Nations

- •UK
- •Germany
- •Netherlands
- •Australia
- •US
- •Spain
- •Italy

------- C/DIT Testing ------

Phase 3&4
(2006/7) – IABM Testing in Joint Engineering Environment

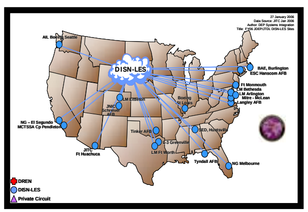
- •UK AWACS
- •PATRIOT
- •TAOM
- •SSDS
- •AEGIS (2)
- •ACDS
- •E-2C
- •F-18

Phase 2
(2005)
Fix developing Implementation of MIL STD 6016C

- •Patriot
- •AEGIS
- •E-2C

Phase I
(2003)
Validate SIAP algorithms in legacy

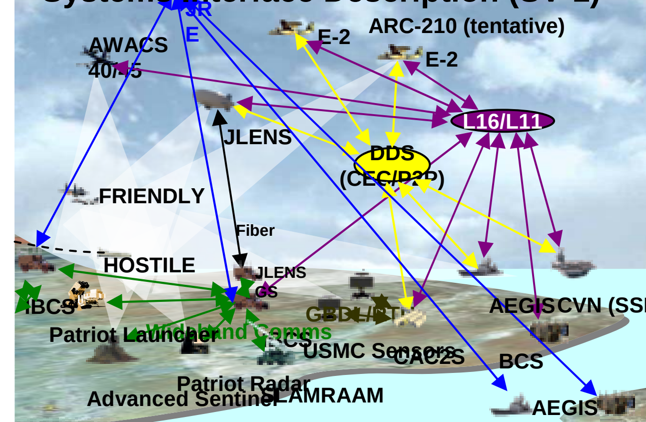
- •Patriot
- •AEGIS
- •E-2C



Joint Test Env.: (2001) Joint I/O Capabilities & Limitations (4 Joint Nodes)

Navy DEP - HWIL for Deployers (13 Nodes)

SIAP Pathfinders and Connectivity: Systems Interface Description (SV-1)



1998 2001 2005 2006/7 2010 2015

Joint, Distributed Engineering finds problems early, reduces costs, and improves interoperability: the "Force Multiplier" for the 1,000-ship Navy.

Integral Fire 07

(AF-ICE, USJFCOM J89, SIMAF, JMETC, JC2 JCAS, JTEM, NSWC DN)

Description: establish a Joint persistent test environment to support Joint Command and Control (JC2), Joint Close Air Support (JCAS) Assessment for USJFCOM; and Air Force Secretary on the Warfighter Warfighter Forwarder (WWF) integration

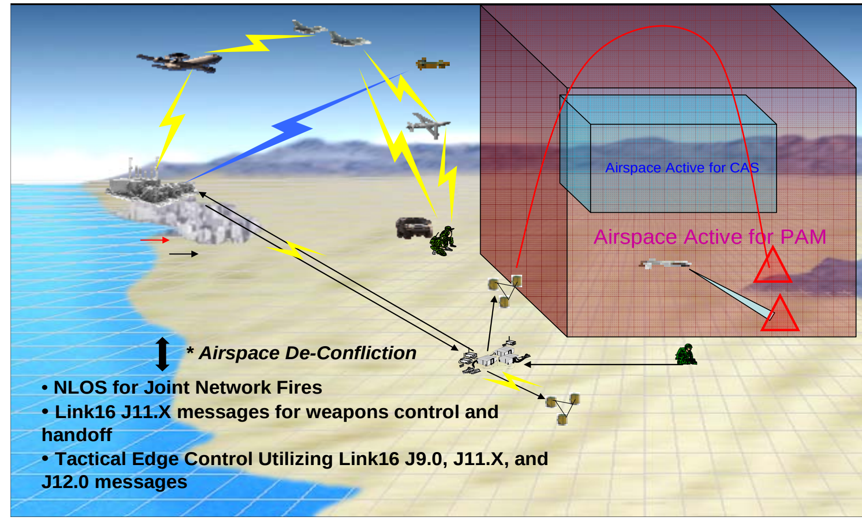
Objectives:

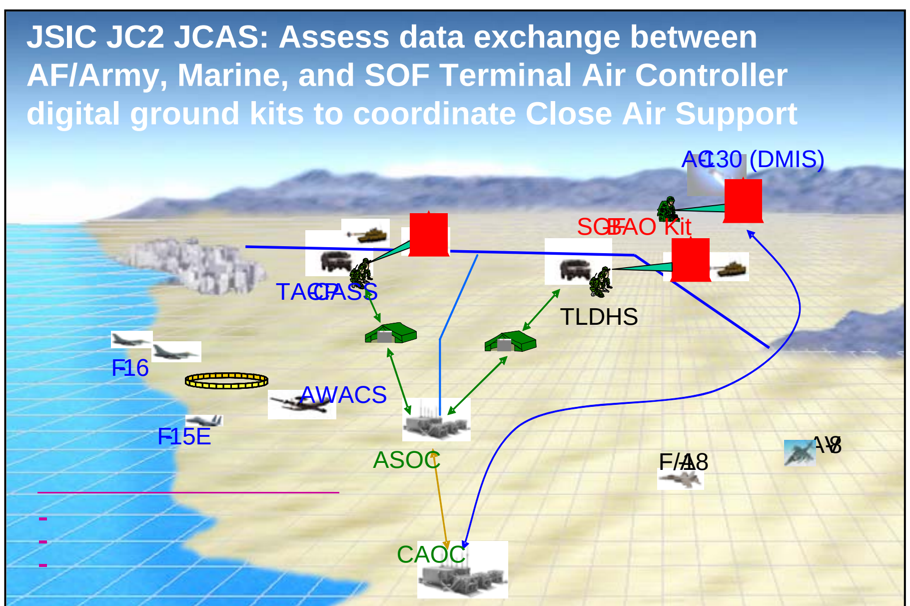
• Conduct a technical assessment of JCAS in response to real time requests.

• Evaluate Methods and Processes C2 airspace de-confliction between Army NLOS and Net enabled weapon (NEW) (Air Force and Navy).

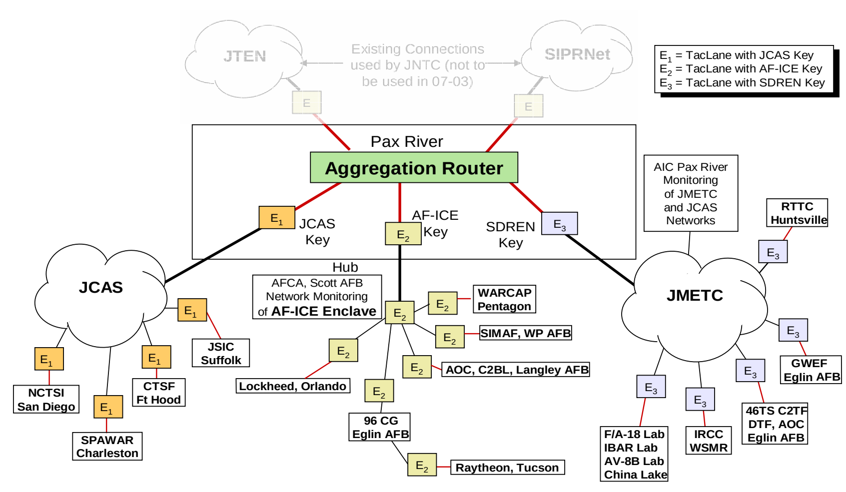
• Machine to Machine re-tasking of strike platforms and NEW from the Air Operations Center (AOC).

JTEM (Non Line of Sight NEW) Warplan Warfighter Forwarder





LVC JME Infrastructure



T&E Facility Examples
Ocean & Coastal Ranges and Facilities

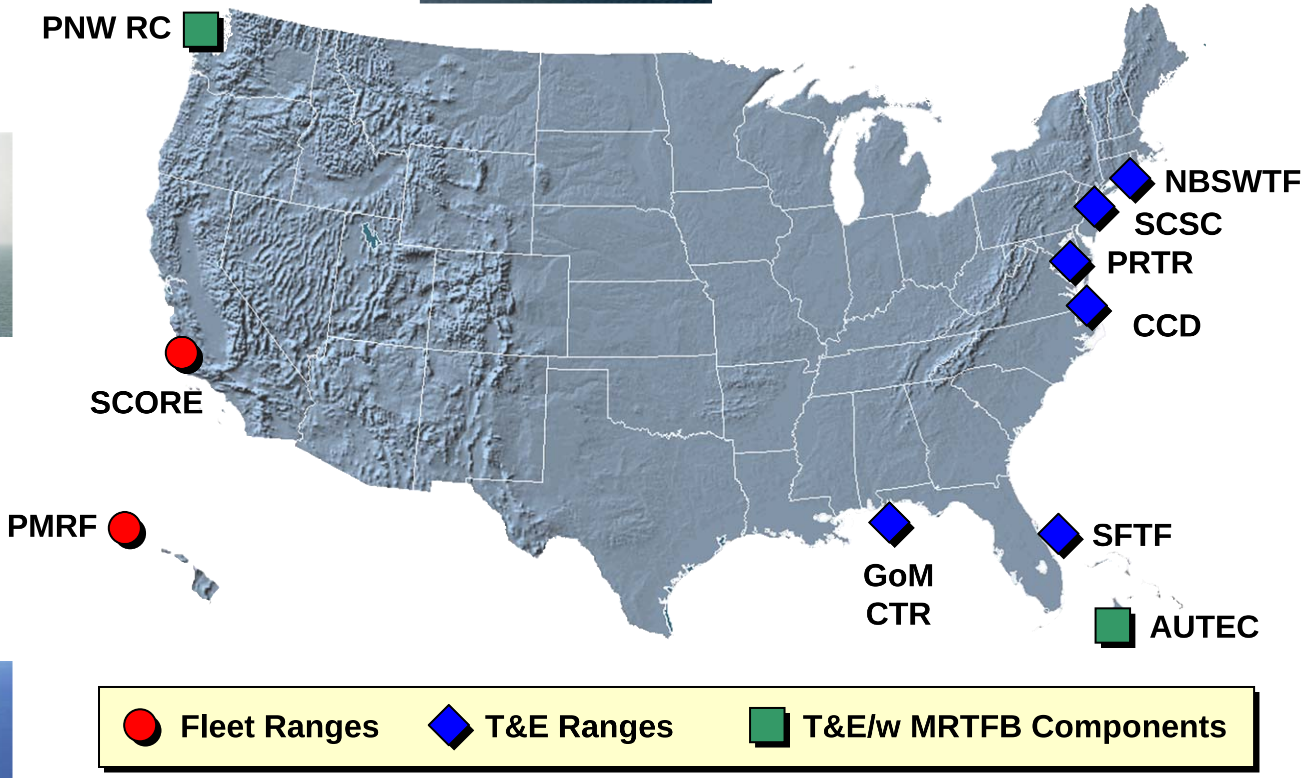
Pacific Northwest Range Complex

Narragansett Bay Shallow Water Test Facility

Potomac River Test Range

Surface Combat Systems Center

Southern California Offshore Range



Combatant Craft Division

South Florida Test Facility

Pacific Missile Range Facility

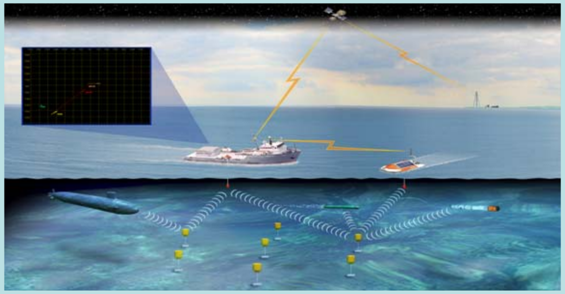
Gulf of Mexico Coastal Test Range

Atlantic Undersea Test and Evaluation Center

NAVSEA NAVAL SEA SYSTEMS COMMAND SEA 05 Naval Systems Engineering Directorate

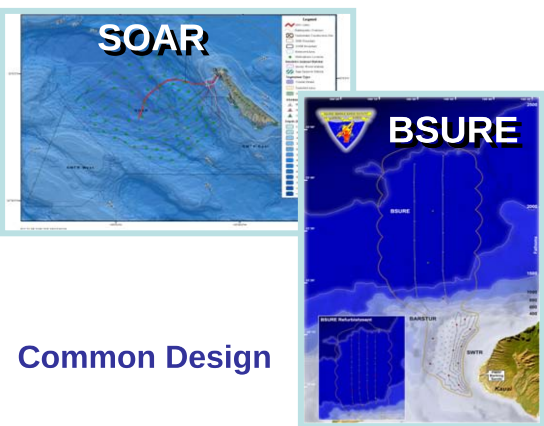
Initiative: Undersea Ranges Consolidation & Collaboration (NUWCKPT, NPT)

Portable Range Programs Reduced From 12 to 5
Cost Avoidance ~$3M



Eliminating Overlap

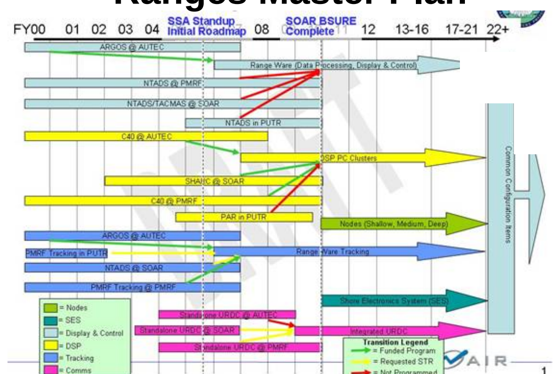
One Contract for Upgrades at 2 Ranges
Cost Avoidance ~$9M



Common Design

Sponsors: NRO
Partners: PMA205, SCORE, PMRF, LMC/L3/Maripro

USW T&E and Training Ranges Master Plan



Identifying & Leveraging Common Systems

Inventoried East Coast Range Cable given to KPT's Nanoose Range for Repair
Cost Savings $800K

Collaboration

Pinger Consolidation Across Warfare Centers
Cost Savings = $150K/yr

Common Equipment

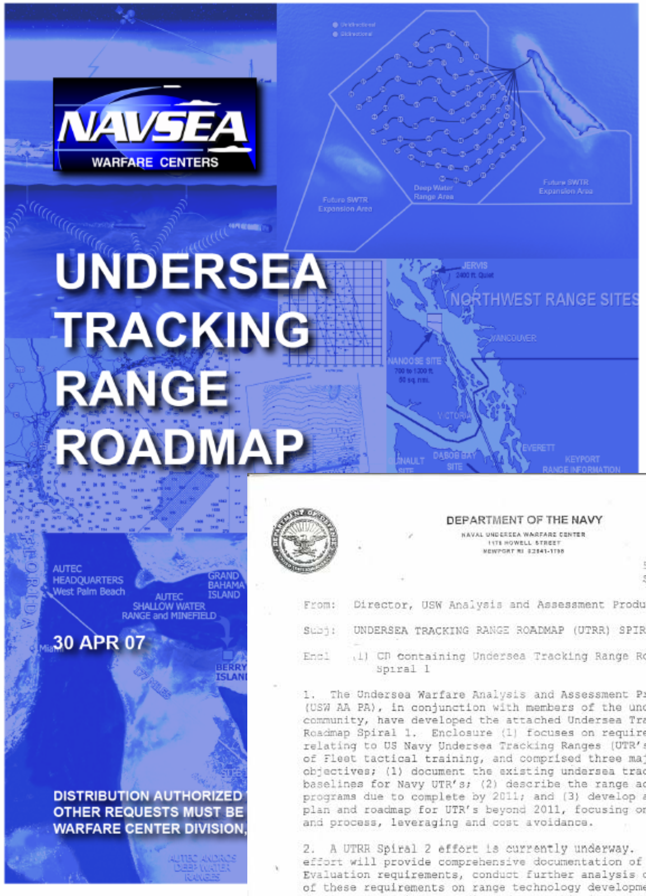
Reduce Cost

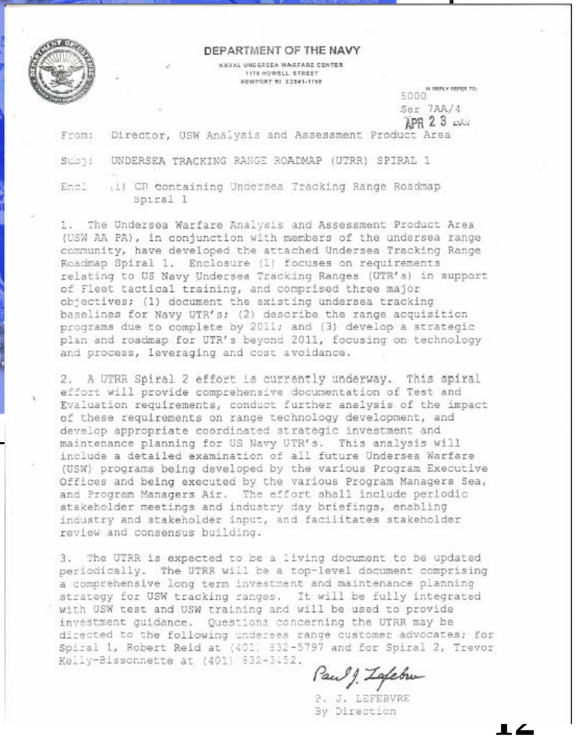
Assess Using IMPASS (Gun Firing) System for Portable Surface Ship Radiated Noise Measurements

Leveraging Existing Systems Future Multi-use Cost Savings TBD

Undersea Tracking Range Roadmap

- Comprehensive roadmap of USW tracking range requirements (T&E & Training)
- Held UTR T&E requirements forum with PEO's, COTF, FFC
- Provides investment guidance for near, mid, and long term
- Identifies shortfalls or gaps in resources and shared approaches to USW ranges technology
- Completed Phase 1, conducting Phase 2
- Documents efforts required for the current ranges out to FY20.
- Proposes potential technologies and range architecture





DEPARTMENT OF THE NAVY
NAVAL UNDERSEA WARFARE CENTER
1176 HOWELL STREET
NEWPORT RI 02841-1708

IN REPLY REFER TO:
5000
Ser 7AA/4
APR 23 2007

From: Director, USW Analysis and Assessment Product Area

Subj: UNDERSEA TRACKING RANGE ROADMAP (UTRR) SPIRAL 1

Encl (1) CD containing Undersea Tracking Range Roadmap Spiral 1

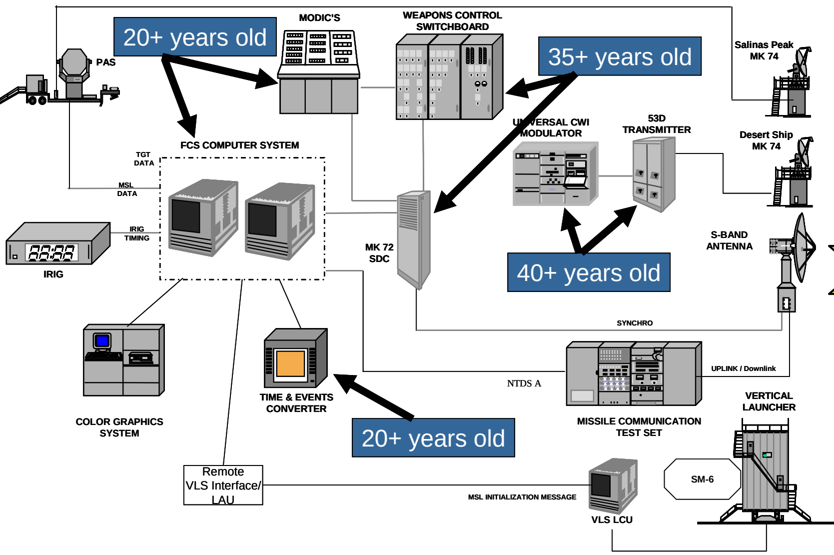
1. The Undersea Warfare Analysis and Assessment Product Area (USW AA PA), in conjunction with members of the undersea range community, have developed the attached Undersea Tracking Range Roadmap Spiral 1. Enclosure (1) focuses on requirements relating to US Navy Undersea Tracking Ranges (UTR's) in support of Fleet tactical training, and comprised three major objectives; (1) document the existing undersea tracking baselines for Navy UTR's; (2) describe the range acquisition programs due to complete by 2011; and (3) develop a strategic plan and roadmap for UTR's beyond 2011, focusing on technology and process, leveraging and cost avoidance.

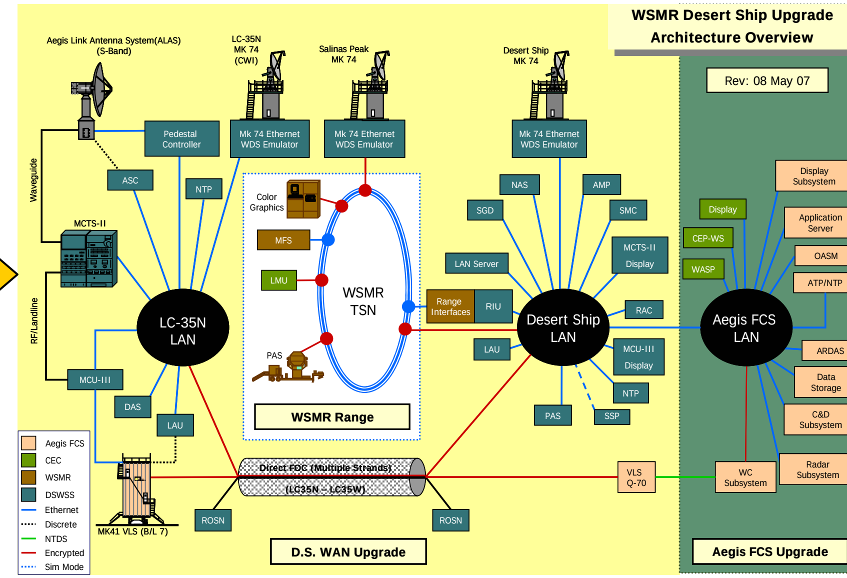
2. A UTRR Spiral 2 effort is currently underway. This spiral effort will provide comprehensive documentation of Test and Evaluation requirements, conduct further analysis of the impact of these requirements on range technology development, and develop appropriate coordinated strategic investment and maintenance planning for US Navy UTR's. This analysis will include a detailed examination of all future Undersea Warfare (USW) programs being developed by the various Program Executive Offices and being executed by the various Program Managers Sea, and Program Managers Air. The effort shall include periodic stakeholder meetings and industry day briefings, enabling industry and stakeholder input, and facilitates stakeholder review and consensus building.

3. The UTRR is expected to be a living document to be updated periodically. The UTRR will be a top-level document comprising a comprehensive long term investment and maintenance planning strategy for USW tracking ranges. It will be fully integrated with USW test and USW training and will be used to provide investment guidance. Questions concerning the UTRR may be directed to the following undersea range customer advocates; for Spiral 1, Robert Reid at (401) 832-5797 and for Spiral 2, Trevor Kelly-Bissonnette at (401) 832-3452.

Paul J. Lefebvre
P. J. LEFEBVRE
By Direction

Initiative: White Sands Missile Range (WSMR) Desert Ship Upgrade





- **Transitioned 20-40 year old specialized Fire Control System (FCS) equipment to an Aegis Open Architecture FCS and COTS based approach.**
- **Supports current and future Integrated Fire Control (IFC) tests to demonstrate Naval and Joint Capabilities**
- **Reduces overall Desert Ship system maintenance cost**
- **OA and COTS approach reduces future upgrade costs**

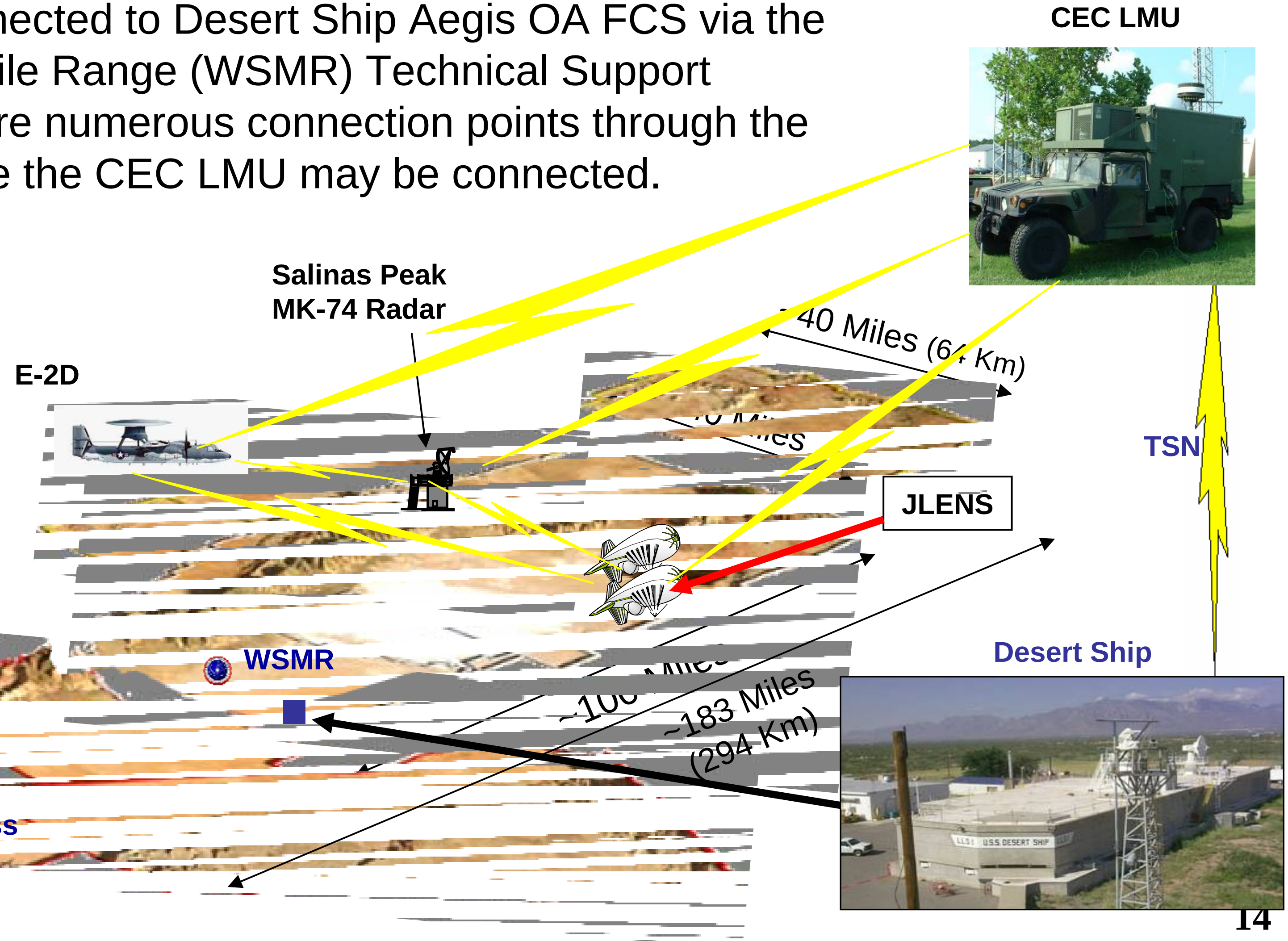
Initiative: White Sands Missile Range (WSMR) Desert Ship Upgrade

Potential Future IFC Test Configurations

The Cooperative Engagement Capability (CEC) Land Mobile Unit (LMU) is connected to Desert Ship Aegis OA FCS via the White Sands Missile Range (WSMR) Technical Support Network. There are numerous connection points through the entire range where the CEC LMU may be connected.

WSMR provides various overland test environments

- Desert
- Mountain

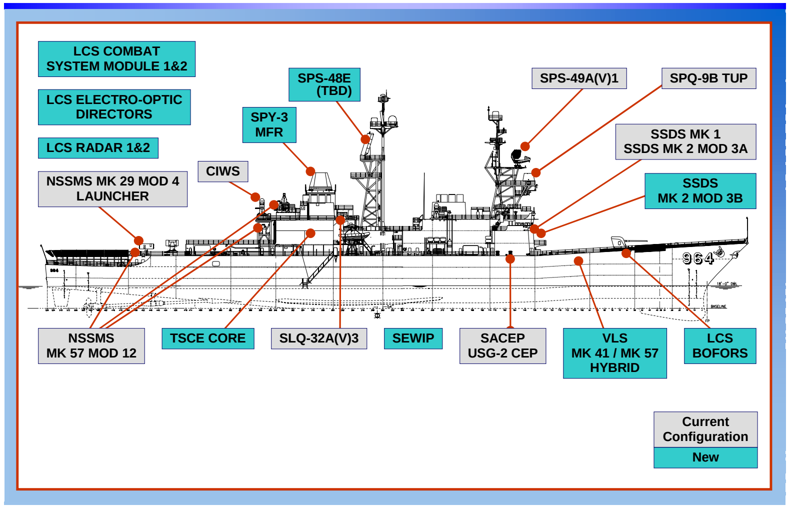


NAVSEA NAVAL SEA SYSTEMS COMMAND SEA 05
Naval Systems Engineering Directorate

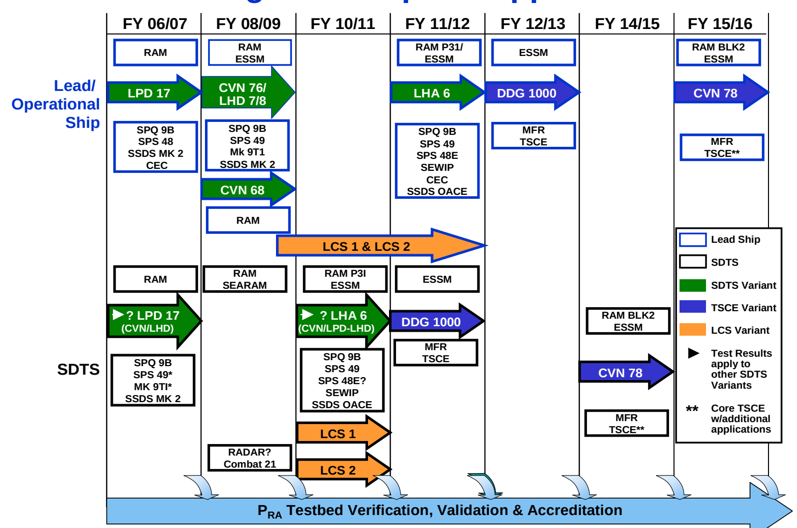
Initiative: AAW SSD T&E Enterprise

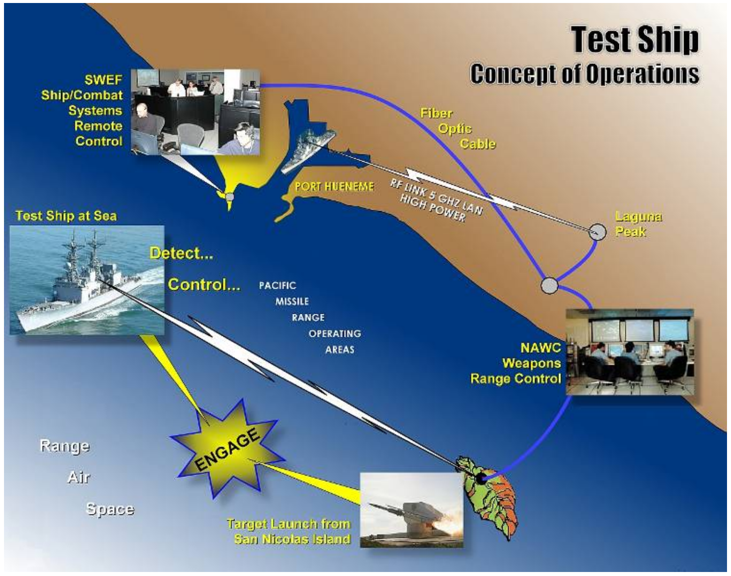
- **PEO IWS Initiative to apply an enterprise approach to program T&E strategies**
- **Integrates SDTS and Lead ship at-sea test events, and P_{ra} Testbed across combat system variants**
  - **–Applicable to LPD 17, LHA 6, DDG 1000, CVN 78, LCS**
  - **–SSDS, RAM, ESSM**
- **Eliminates duplication and optimizes testing; element TEMP(s) still supported**

Self Defense Test Ship
ENTERPRISE Strategy Configuration



Using an Enterprise Approach





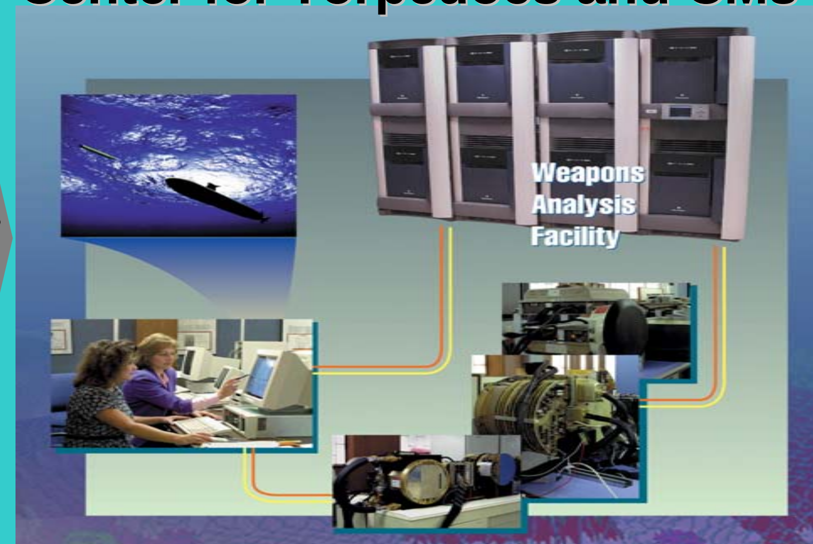
Potential savings of $240 Million, and reduction of 38 missiles

WAF-SMMTT Value to the Warfighter

SUBSCOL NL and NSTCP SMMTT

Proven Connectivity HLA Interface ISDN or use SIPRNET,T1

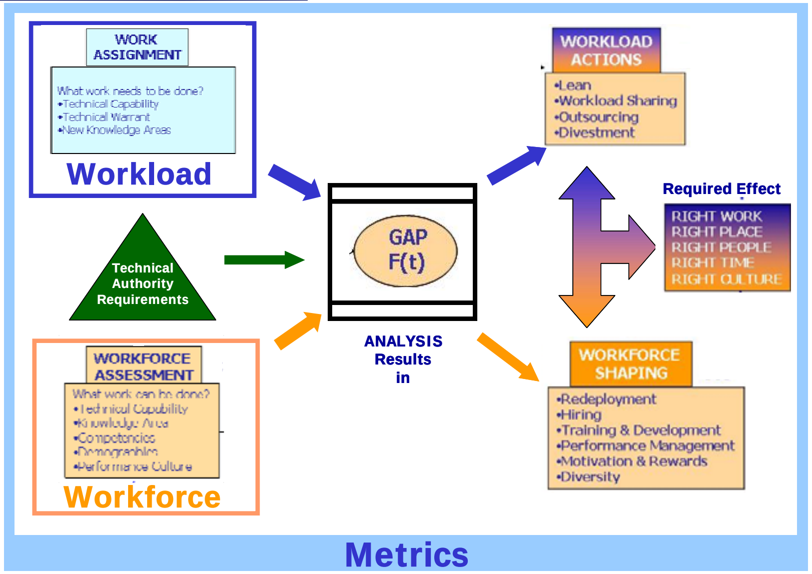
NUWC Simulation and Analysis Center for Torpedoes and CMs



- **Real Torpedo Hardware in the loop and latest weapon software**
- **High fidelity threat models, CMs, and high fidelity tactically significant environments**
- **An excellent test bed to preview, and test Combat Control and APB Weapon System and HSI improvements prior to costly at-sea firings**
- **Proven HLA connectivity**
- **Leverage the latest exploitation for training in the employment of the latest torpedoes in operationally relevant scenarios. Used as part of SCC training since Oct 2004. Utilized for mission-specific Pre-Deployment Training**

Initiative: NAVSEA T&E Human Capital Strategy

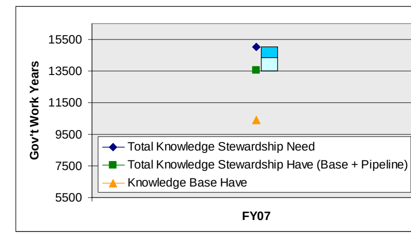
STRATEGY



ASSESSING WORKFORCE HEALTH

Measure TC Health by Knowledge Area (KA)
(e.g. Test & Evaluation)

Yields

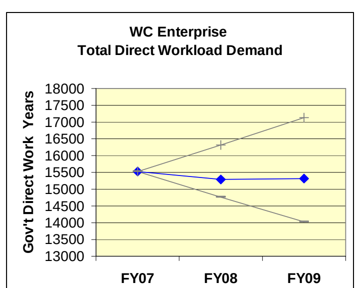


Gap Assessment

ASSESSING WORKLOAD DEMAND

Assign Workload by Technical Capability (TC)

Yields



Workload Trends

WORKFORCE SHAPING ACTIONS

Hire Or Redeploy based on TC& KA Health

Human Capital			
FY07 Workforce Hiring by Site TC	FY06 Health Assessment	Planned	Current YTD
S&T		5	1
TC1		30	12
TC2		20	0
TCX		5	0
TCY		4	0
Business Operations		5	1
Total		69	14

Directions: Direct S&T Work is counted in appropriate TC

Develop by 5VM Career Path
(e.g. Test & Evaluation)

Counter IED Device Testing
(NSWC Corona, Dahlgren, NAVEODTECHDIV, PMS408)




Tasking

Assessment of effectiveness of CREW systems for dismounted troops, wheeled vehicles, and riverine patrol boats.

- Quick Reaction Mounted & Dismounted CREW - Counter Remote Control Improvised Explosive Device Electronic Warfare

Challenges

- Compressed acquisition process requires demanding OPTEMPO.
- Transform process for assessment of NAVY weapons systems for assessment of systems used in ground combat environment to counter asymmetric threat – IED's.

Accomplishments

- On-site at Yuma Proving Grounds Az, for data collection, analysis & operator support
- Author Effectiveness reports
- Testified as SME at source selection board Feb 07.

NAVSEA NAVAL SEA SYSTEMS COMMAND SEA 05 Naval Systems Engineering Directorate

M&S Initiative: Envisioned Roadmap Towards M&S of the Full Ship Shock Trial

Integrated M&S of FSST

Business Strategies

•**Uncoupled** simulators of shock load.
•**Global** energy equations (include fragment energy).

•**Certify** LSDYNA, ABAQUS, NASTRAN, DYSMAS.. in accordance with specified capabilities and limitations.

• **Collaborative Investment** on most critical enablers.

• **End to end coupled M&S** with imbedded beam analogy, joint analogy, cavitation load analogy, fragment energy balance models.

M&S Technologies

Structure Dynamics Under Shock /Blast load.
•Beam-column, Pipe-structure connection, Bolted joints.
•Shock transmission across joints.
Fluid-Structure Interface
•CFD Modeling of blast intrusion.
•CFD cavitation interaction with structure.
•Adaptive FEB for fluid structures.
Numerical Models
•Non-reflecting B.C.'s

Fracture & fragment Modeling

Account for effects of as-builts for accuracy
•use of imaging (both EM and acoustic) for direct, near-automatic discretization & meshing.

T&E Engineering

• **Integrated UNDEX** whipping resistance assessment model.
•**Alternate T&E to support critical gaps.**

FSST
•Peak pressure, total impulse sensitivity calibration.
•Fast transient response instrumentation.
•Pseudo velocity shock spectrum.
•High speed actuator for shock testing, Multi-axis transducers.

Basic Science of Material

Visco-elastic, non-linear, non-isotropic, strain rate-stress constitutive models.
Composite failure models, fracture mechanics.

2006 **2011** **2016**

Future of NAVSEA T&E

Mature Test Evaluation & Analysis Competency

- Support Navy T&E BOD integrated investment strategies
- Create end-to-end transparency in demand signals, improve execution capacity and efficiency, reduce cost of execution and ultimate deliverables, and improve customer satisfaction

Enable System Engineering To Support Acquisition via Integrated Strategic Planning

- Emphasize enterprise integrated solutions versus platform or singular domain focus across PEO T&E Directors, HQ & Warfare Centers T&E Executive activities
- Enable Navy T&E in a Joint Environment
- Enable Affordable T&E of Open Architecture Systems

Perspectives on Acquisition, Test, and Early Fielding of UAV Systems

Curt Cook

DOT&E

Perspectives

- **<u>ACTD legacy:</u>** Departure from the intent of ACTD process in most UAS programs set stage for numerous negative consequences affecting the systems' performance and pace of maturity.

- **<u>Dual-program problem:</u>** Development of the intended program continued concurrent with early fielding of immature systems. This created a dual-program problem (a deployed system and an intended system, both under development).

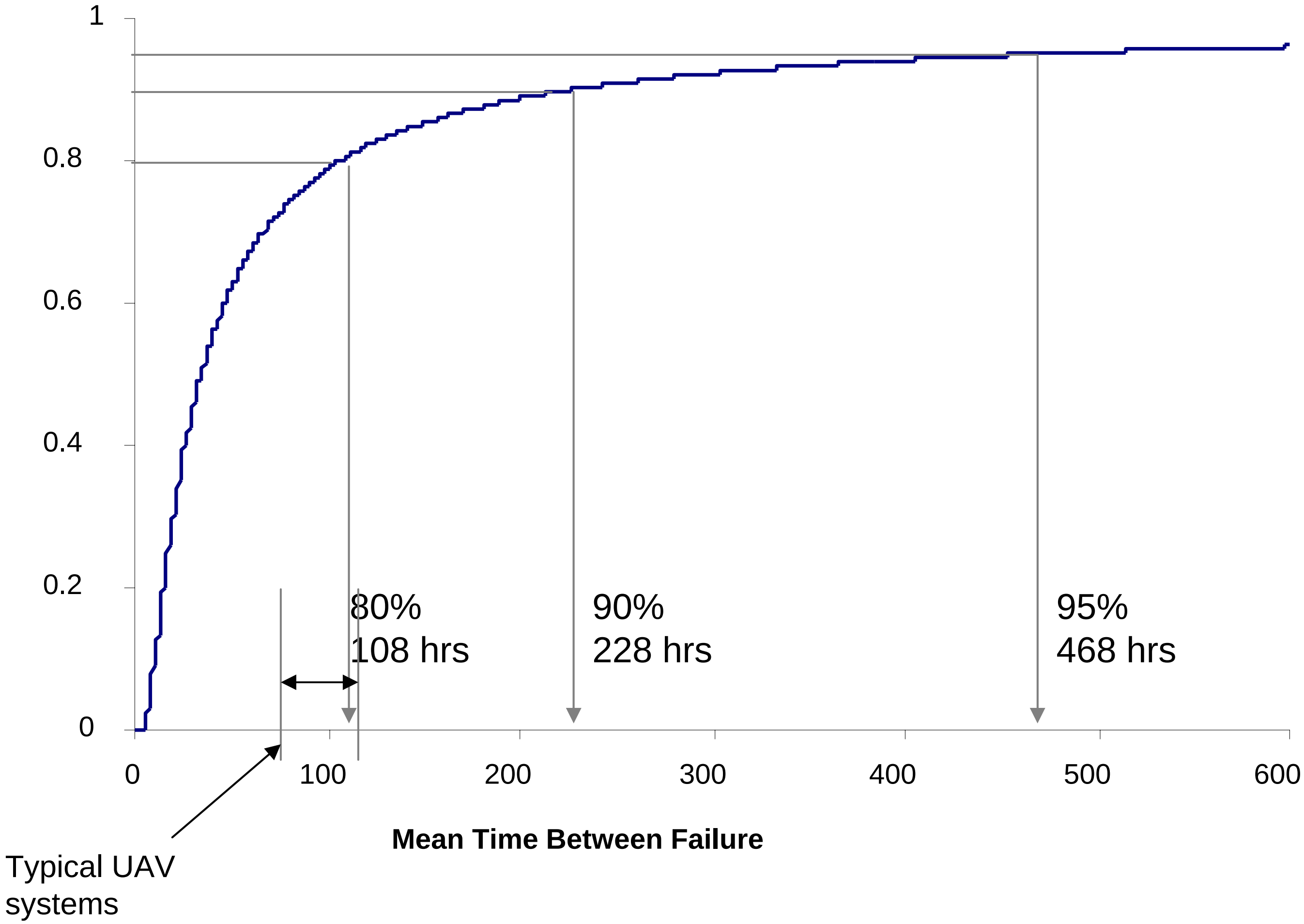
- **<u>Limited meaningful testing:</u>** As acquisition programs of the intended system took shape, service acquisition leadership and program management demonstrated an aversion to end-to-end, mission level OT&E (excepting few programs).

- **<u>Performance:</u>** The single most important performance characteristic for unmanned systems should have been high reliability--this has not been the case.

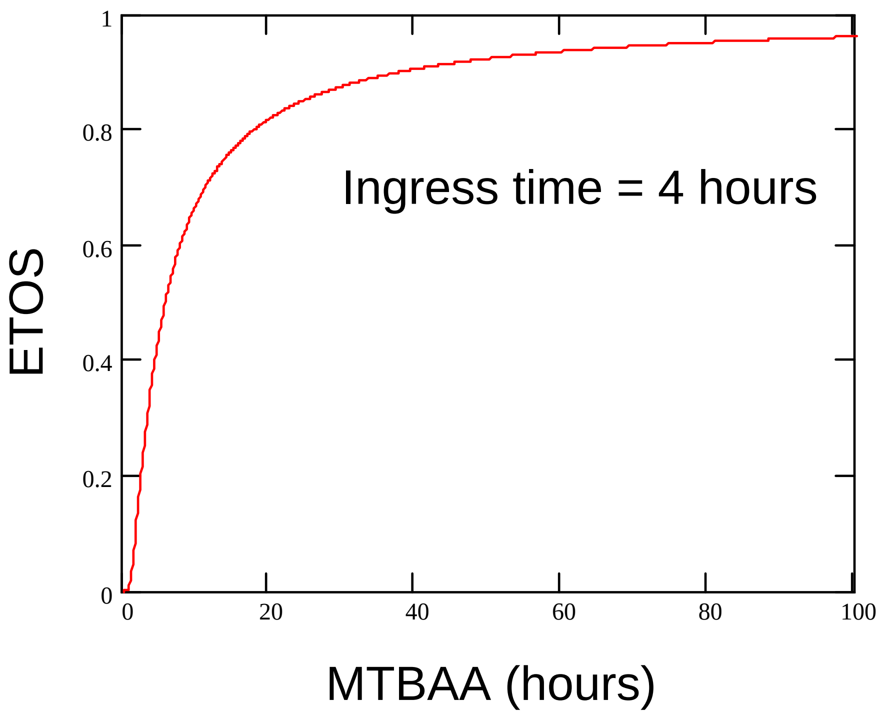
What should be done now?

1. Fielded systems: Invest in reliability growth and improvements to suitability.
   - Any other performance improvements must positively contribute to improved reliability and availability of the overall system.
   - Defend costs for spares, maintainability improvements, and deployability of systems.
   - Improve initial CONOPS: Document and spread the word on what worked, what didn’t work, and what needs to be fixed in the integration of UASs with ground and air combat units.
2. Systems under development: Accomplish the fundamentals necessary for a successful program:
   - Ensure sufficient requirements traceability
   - Re-evaluate requirements for reliability and maintainability
   - Complete and validate concept of operations and support
   - Plan, resource and complete adequate developmental and operational testing

Probability of Completing a 24 Hour Mission Without a Failure



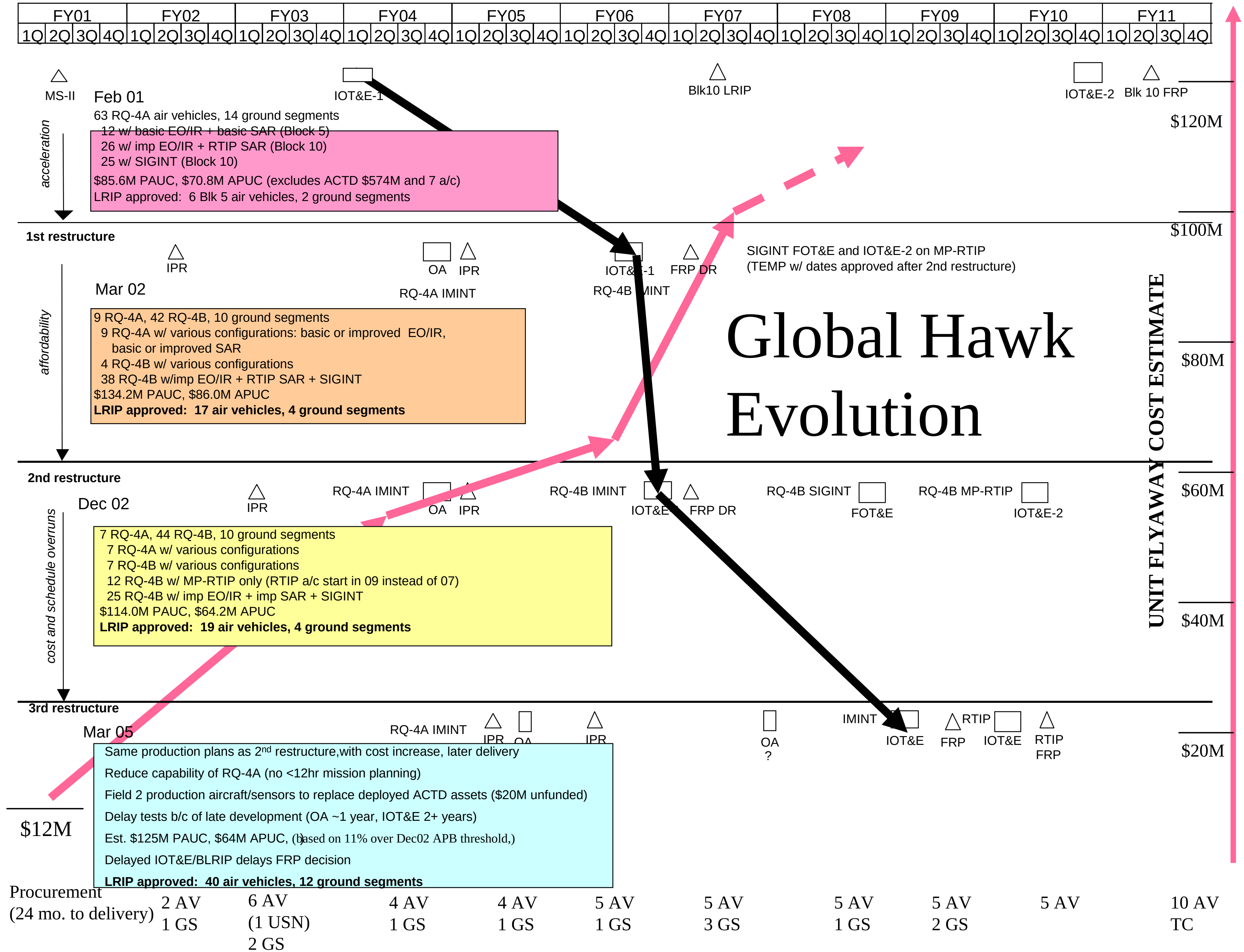
Effect of Air Aborts on Effective Time On Station



<u>Assumes:</u>

- •100 percent availability
- •Relief on Station (unlimited aircraft simultaneously airborne)
- •Instantaneous launch on request (no start up time)
- •No ground aborts
- •Exponential air abort distribution

Shows upper bound on ETOS imposed by air aborts


FY01 FY02 FY03 FY04 FY05 FY06 FY07 FY08 FY09 FY10 FY11
1Q 2Q 3Q 4Q
MS-II
IOT&E-1
Blk10 LRIP
IOT&E-2
Blk 10 FRP
Feb 01
63 RQ-4A air vehicles, 14 ground segments
12 w/ basic EO/IR + basic SAR (Block 5)
26 w/ imp EO/IR + RTIP SAR (Block 10)
25 w/ SIGINT (Block 10)
$85.6M PAUC, $70.8M APUC (excludes ACTD $574M and 7 a/c)
LRIP approved: 6 Blk 5 air vehicles, 2 ground segments
acceleration
$120M
1st restructure
IPR
OA
IPR
RQ-4A IMINT
FRP DR
SIGINT FOT&E and IOT&E-2 on MP-RTIP
(TEMP w/ dates approved after 2nd restructure)
$100M
Mar 02
9 RQ-4A, 42 RQ-4B, 10 ground segments
9 RQ-4A w/ various configurations: basic or improved EO/IR, basic or improved SAR
4 RQ-4B w/ various configurations
38 RQ-4B w/imp EO/IR + RTIP SAR + SIGINT
$134.2M PAUC, $86.0M APUC
LRIP approved: 17 air vehicles, 4 ground segments
affordability
Global Hawk Evolution
UNIT FLYAWAY COST ESTIMATE
$80M
2nd restructure
Dec 02
IPR
RQ-4A IMINT
OA
IPR
RQ-4B IMINT
FRP DR
RQ-4B SIGINT
FOT&E
RQ-4B MP-RTIP
IOT&E-2
$60M
7 RQ-4A, 44 RQ-4B, 10 ground segments
7 RQ-4A w/ various configurations
7 RQ-4B w/ various configurations
12 RQ-4B w/ MP-RTIP only (RTIP a/c start in 09 instead of 07)
25 RQ-4B w/ imp EO/IR + imp SAR + SIGINT
$114.0M PAUC, $64.2M APUC
LRIP approved: 19 air vehicles, 4 ground segments
cost and schedule overruns
$40M
3rd restructure
Mar 05
RQ-4A IMINT
IPR
IPR
OA
?
IMINT
IOT&E
FRP
RTIP
IOT&E
RTIP
FRP
$20M
Same production plans as 2nd restructure,with cost increase, later delivery
Reduce capability of RQ-4A (no <12hr mission planning)
Field 2 production aircraft/sensors to replace deployed ACTD assets ($20M unfunded)
Delay tests b/c of late development (OA ~1 year, IOT&E 2+ years)
Est. $125M PAUC, $64M APUC, (based on 11% over Dec02 APB threshold,)
Delayed IOT&E/BLRIP delays FRP decision
LRIP approved: 40 air vehicles, 12 ground segments
$12M
Procurement
(24 mo. to delivery)
2 AV
1 GS
6 AV
(1 USN)
2 GS
4 AV
1 GS
4 AV
1 GS
5 AV
1 GS
5 AV
3 GS
5 AV
1 GS
5 AV
2 GS
5 AV
10 AV
TC

Major New Initiatives Affecting T&E

- McQueary/Young Policy Provisions

- McQueary Goals and Priorities

- New Approaches for System Development, Testing and Fielding

McQueary/Young Policy Revisions

- Fundamental Purpose of T&E : Provide Knowledge to Assist in Managing Risks in System/Capability Development, Production, Operations & Sustainment
  - Measure Progress in Both System & Capability Development
  - Provide Knowledge of System Capabilities & Limitations to the Acquisition and User Communities
  - Bring to Bear Expertise at the Outset of a System’s Life Cycle
  - Identify Technical, Operational and System Deficiencies Early

McQueary/Young Policy Revisions

- DT&E and OT&E Integrated & Seamless throughout Life Cycle
- Evaluations Include Comparison with Current Mission Capabilities to Determine Measurable Improvements
- Assess Improvements to Mission Capability and Supportability Based on User Needs -- Report in Terms of Operational Significance
- Evaluations Include All Available & Relevant Data
- Conduct T&E in a Continuum of Live, Virtual & Constructive Environments

McQueary Goals and Priorities

- Improve Suitability
- Enhance Operational Realism in Early Tests, including DT&E
- Provide Timely Performance Information to the Warfighters
- Conduct Mission-Based (End-to-End) OT&E
- Improve Operational Test Resources

New Approaches for System Development, Testing and Fielding

- Competitive Prototyping
- Capabilities-Based Acquisition
- Rapid Acquisition of Systems driven by Urgent GWOT Requirements
- New Emphasis on Testing in a Joint Environment

Challenges for Test and Evaluation (T&E) in the Defense System of Systems Environment

Dr. Judith Dahmann
The MITRE Corporation

Darlene Mosser-Kerner
OUSD AT&L SSE/DTE

System of Systems:

A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities. **DoD Defense Acquisition Guide**

Why Systems of Systems (SoS)?

- **SE is a critical enabler for systems acquisition**
  - **Today's acquisition process focuses on the development of systems**
- **Most military systems today are part of an SoS whether or not explicitly recognized**
  - **Most systems are created & evolve without <u>explicit</u> SE at the SoS level**
  - **Traditionally the combination of systems to meet operations has been in context of operations**
- **Given increased networking and ranges of both sensors and weapons, it is becoming important to recognize SoS in development and systems engineering**
  - **SoS dependencies have an impact on <u>development and engineering of systems</u>**
  - **DoD is <u>recognizing SoS</u> from both a management and engineering perspective**

Objective

- Ensure the DoD SE community is equipped to support war fighting capabilities at the system, system of systems, and enterprise levels by
  - Understanding the nature of the current and emerging development environments and the challenges they pose for SE
  - Identifying best practices in conduct of SE in supporting development and acquisition
  - Providing enabling policy, guidance, education and training

What Are We Doing with SoS and SE?

- Completed SoS SE Guide v.1.0 in December 2007
- Executed six month 'pilot phase'
  - SoS practitioners, research teams and industry
  - Structured walkthrough of the draft guide contents to capture their experience
- Pilot results
  - Identified key SoS SE elements and principles
  - Identified SoS SE issues which require further attention
- Socializing results (INCOSE, IEEE, NDIA, others)
- Next steps
  - Update DoD SE Guides (SEP, DAG) for SoS considerations
  - Plan for DAU Continuous Learning Module in FY08
  - Implement FY08 activities to address identified issues
    - Testing

A mechanism to share emerging insights on SoS and implications for SE

Pilot Participants

Objective of the pilots was to gain a 'boots on the ground' perspective

Researchers / FFRDCs

INCOSE: International Council on SE
MIT: Massachusetts Institute of Technology
MITRE: MITRE Corporation
Purdue: School of Engineering
SEI: Software Engineering Institute
Stevens: Institute of Technology
USC: University of Southern California
UCSD: University of California San Diego

NDIA: National Defense Industry Assoc.
Australia: Defence Materiel Organisation

SE Practitioners

ABCS: Army Battle Command System
AOC: Air Operations Center
BMDS: Ballistic Missile Defense System
CAC2S: Common Aviation Command & Control System
DCGS-AF: Distributed Common Ground Station
DoDIIS: DoD Intelligence Information System
FCS: Future Combat Systems
MILSATCOM: Military Satellite Communications
NIFC-CA: Naval Integrated Fire Control – Counter Air
SR: Space Radar
NSA: National Security Agency
NSWC: Naval Surface Warfare Center Dahlgren
PEO GCS: Ground Combat Systems
SIAP: Single Integrated Air Picture
SMC: Space and Missile Systems Center
TMIP: Theater Medical Information Systems – Joint
USGC: US Coast Guard C2 Convergence

Emerging Insights from SoS Pilots

SoS: Is It New?

- **Most military systems today are part of an SoS whether or not explicitly recognized**
  - **Most systems are created and evolve without <u>explicit</u> SE at the SoS level**
- **A formal SoS comes into existence when something occurs to trigger recognition of SoS**
- **An organization is identified as 'responsible for' the SoS 'area' along with definition of the objective of the SoS**
  - **Typically does not include changes in ownership of the systems in the SoS**
- **The SoS is then structured**
  - **Membership is defined starting with identification of systems in the SoS**
  - **Processes and organizations are established for the SoS, including SE**

SoS in the DoD is not new;
Recognizing SoS in development, and recognizing SoS SE is new

What Does SoS Look Like in the DoD Today?

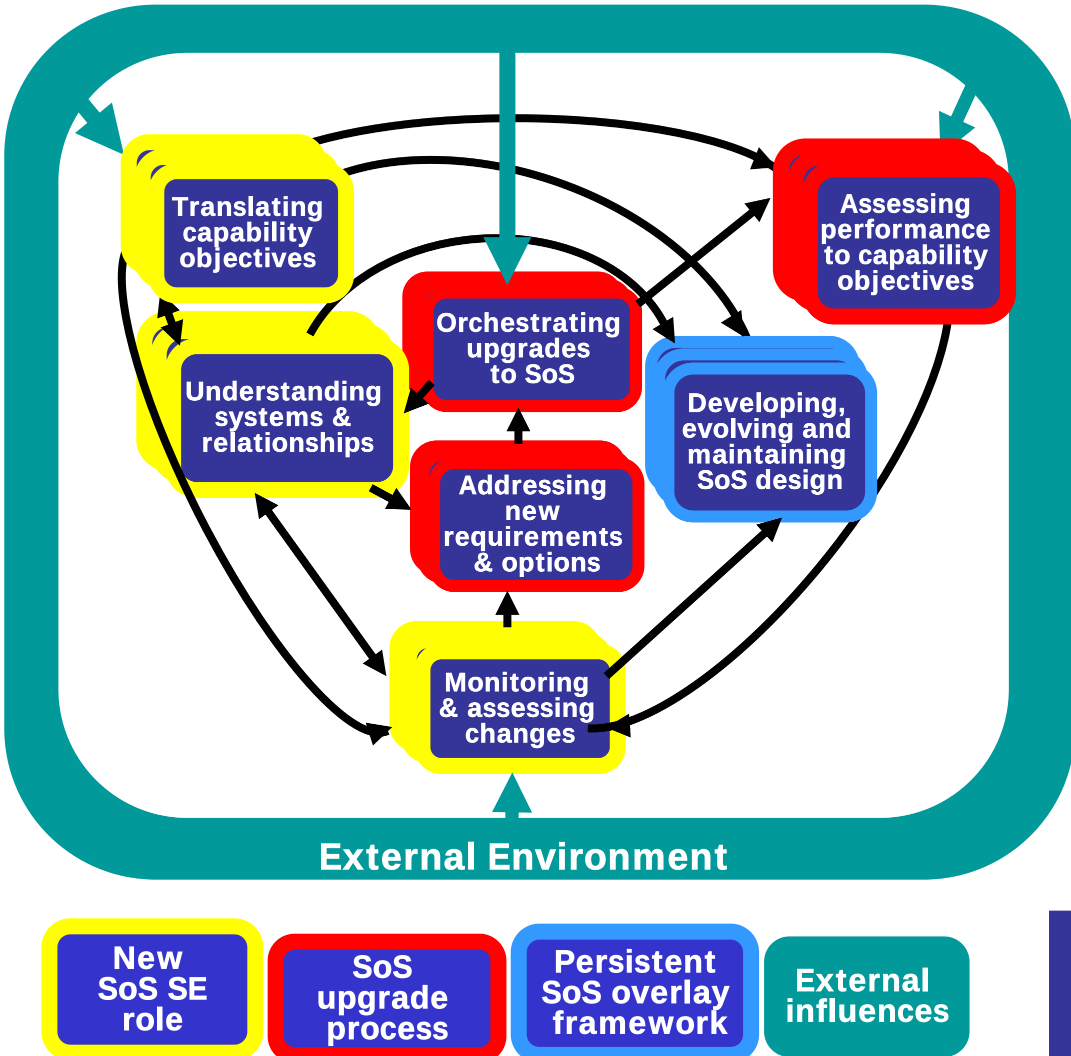
Insights From Pilots

- Typically an overlay or ensemble of individual systems brought together to satisfy user capability needs
- Not new acquisitions per se
  - Cases like FCS are extremely rare and, in practice, still must integrate with legacy systems
- SoS 'manager' does not control the requirements or funding for the individual systems
  - May be in a role of influencing rather than directing, impacts SE approach
- Focus of SoS is on evolution of capability over time
- A functioning SoS takes start-up time but, in steady state, seems well-suited to routine incremental updates

Most military systems are part of an SoS operationally
Only by exception do we manage and engineer at SoS level

Relationship Among Core Elements of SoS SE

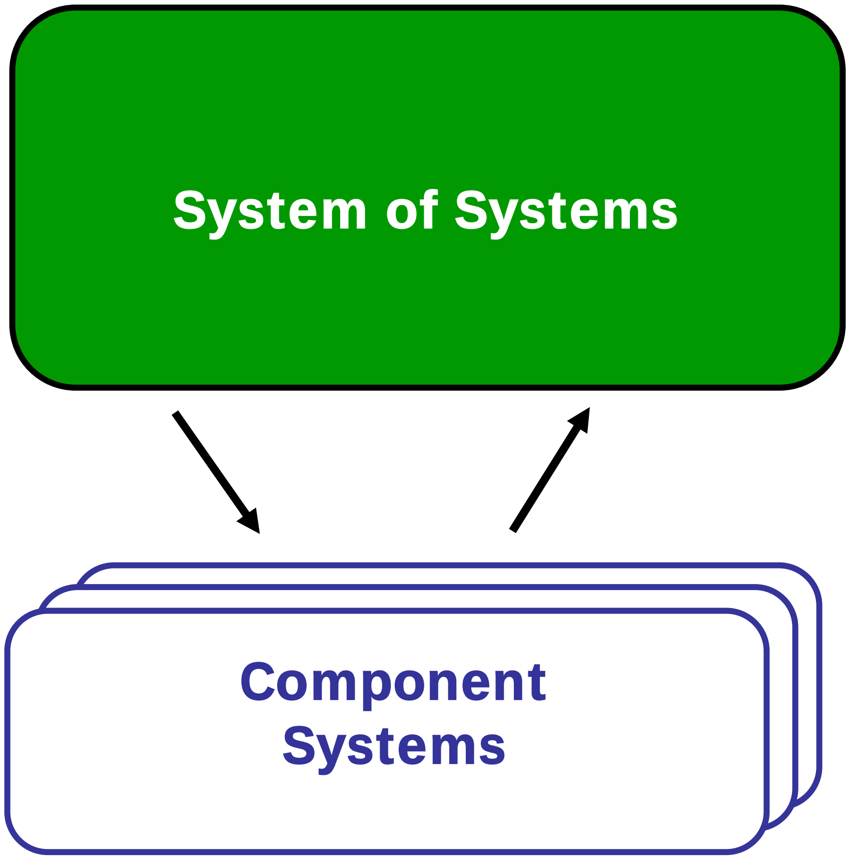
Insights From Pilots



- Translating SoS capability objectives into high level requirements over time
- Understanding the systems in the SoS and their relationships
- Assessing extent to which the SoS meets capability objectives over time
- Developing, evolving and maintaining a design for the SoS
- Anticipating and assessing impacts of potential changes on SoS performance
- Evaluating new and evolving requirements on SoS and options for addressing these
- Orchestrating upgrades to SoS

SoS SE creates and continually applies approaches to accomplish these elements

Where Does T&E Fit into SoS SE?

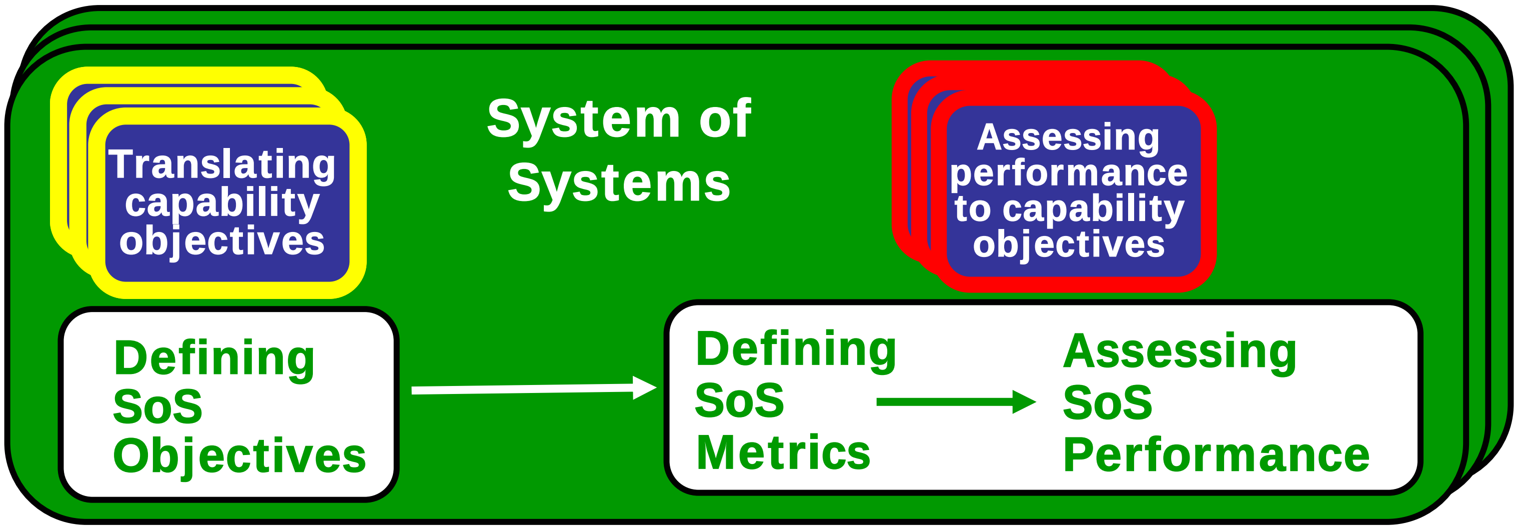


- Focus of SoS engineering on providing end-to-end performance that meets capability needs
- Within the context of the performance requirements and capability limitations of the constituent systems

- Focus in engineering in a single system environment on optimizing to meet specific performance objectives

Creates a tension and balance that must be addressed across the system and SoS levels

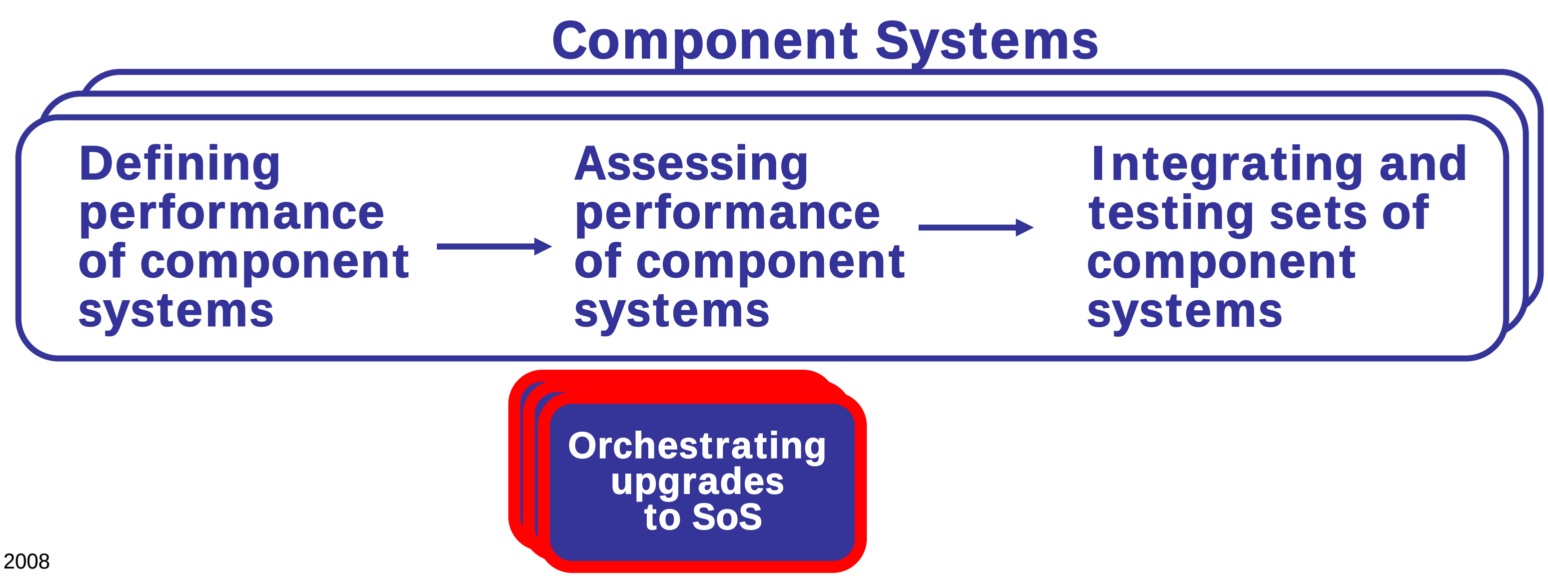
Where Does T&E Fit into SoS SE? SoS



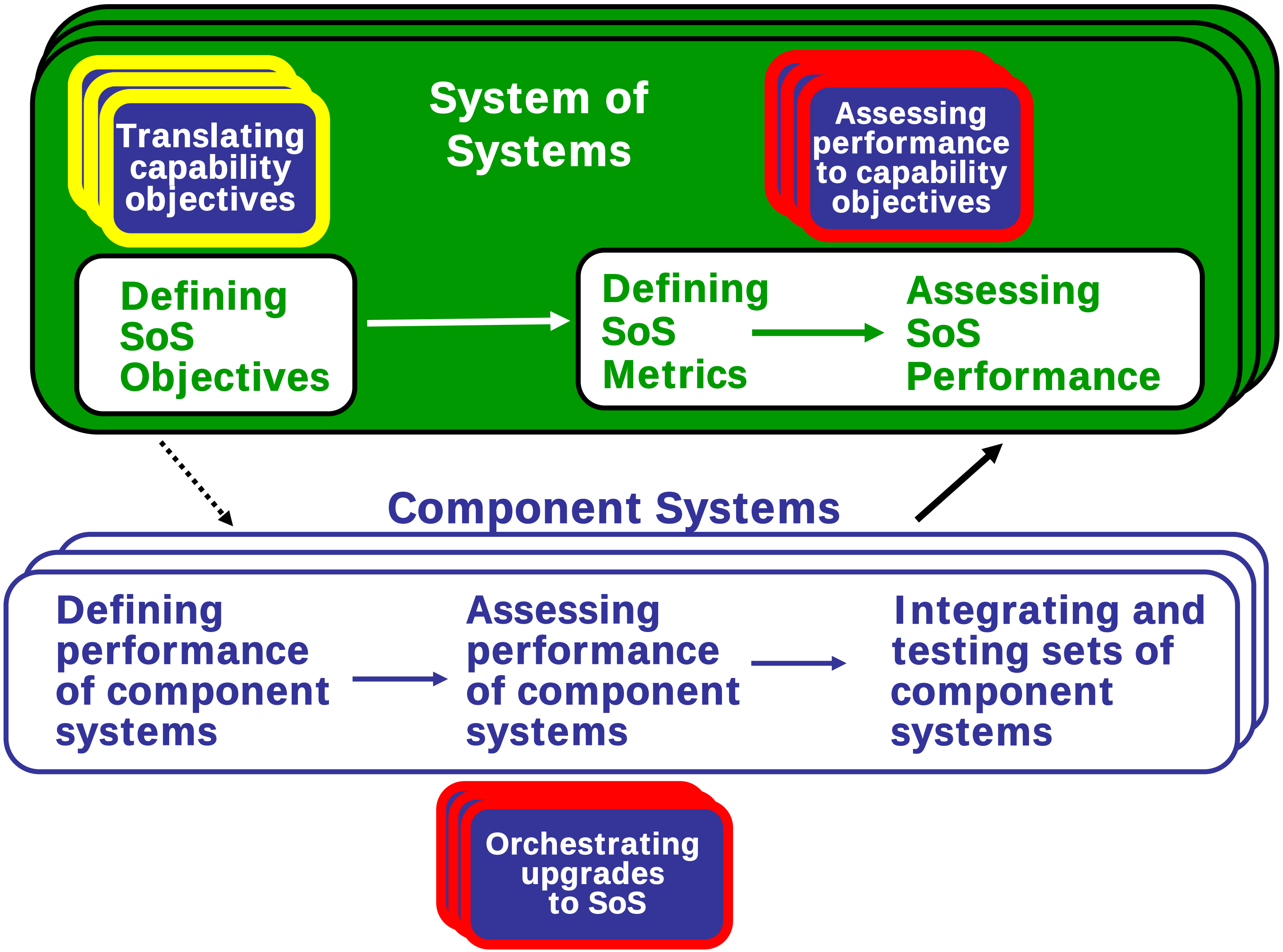
- **SoS metrics and methods assess capability performance as differentiated from capability development**
- **SoS metrics need to focus on SoS performance instead of program execution metrics, and on the intended integrated behavior and performance of the SoS in actual operations**

Where Does T&E Fit into SoS SE? Systems

- **Changes in systems are made to meet SoS objectives**
  - **Typically done as part of the system development and test process**
  - **Include system testing as well integration and test across sets of system**



Where Does T&E Fit into SoS SE?
SoS and Systems



SoS T&E Assumptions

- Operational Independence of Systems
  - Each system has a useful purpose outside of the SoS
- Managerial Independence of Systems
  - Each system is acquired and sustained, independent of the other systems
- Evolutionary Development of Systems
  - Each system is developed in operationally useful increments, uncoordinated with the other systems
- SoS provides synergistic capabilities
  - Unique capabilities not available with a single system
  - Synergy works both ways – positive and negative

SoS T&E Thoughts

- Traditional requirements process leads to a “point design”
  - System designs are optimized and tested for individual system requirements
  - SoS applications are not necessarily aligned with initial system purpose
- SoS capability relies on effective interaction between systems
  - Increases emphasis on testing the collective behavior and sustainment of that behavior
- Focus on system capabilities and limitations would provide better knowledge base for SoS application(s)
  - Helps identify useful SoS capabilities
  - Helps identify harmful SoS interactions

SoS T&E Challenges

- Clear Identification of SoS capability requirements
- How much SoS testing is needed?
  - Piggy back on system test (non-interference)
  - Simulations
  - Regression of SoS capabilities and limitations
- SoS Visibility into individual system design and capabilities
  - "White Box" vs "Black Box" system visibility
- Resolution of SoS capability or limitation issues
  - Which system(s) to change? Trade space
  - Requires establishment of a value construct between individual systems
  - Timing may be driven by opportunities

SoS T&E Challenges (cont.)

- Identification of SoS unique test risks
  - How do you identify synergistic weaknesses?
- Infrastructure capability to test SoS
  - May require networked test ranges, labs, models, simulations (technical issues)
  - May require coordinated asset times (management issues)
  - Instrumentation capability including long term field data
  - Data management
  - Sharing of data – including classified and proprietary issues
- Evaluation methodology for SoS
  - Can we scale analysis and system evaluation methods to SoS size?

Next Steps for SoS T&E

Objective

- **Ensure the DoD SE community is equipped to support war fighting capabilities at the system, system of systems, and enterprise levels by**
  - **Understanding the nature of the current and emerging development environments and the challenges they pose for SE**
  - **Identifying best practices in conduct of SE in supporting development and acquisition**
  - **Providing enabling policy, guidance, education and training**

January 29, 2008 3

- **Develop a robust understanding of the challenges and their sources**
- **Assess current initiatives and approaches and**
- **Identify emerging principles and opportunities for new initiatives**
  - **Remove barriers as necessary**

Contact Info

Dr. Judith Dahmann

jdahmann@mitre.org

Darlene Mosser-Kerner

darlene.mosser-kerner@osd.mil

http://www.acq.osd.mil/sse

Contact us to provide feedback and share your experience

Backup

Core Elements of SoS SE

Insights From Pilots

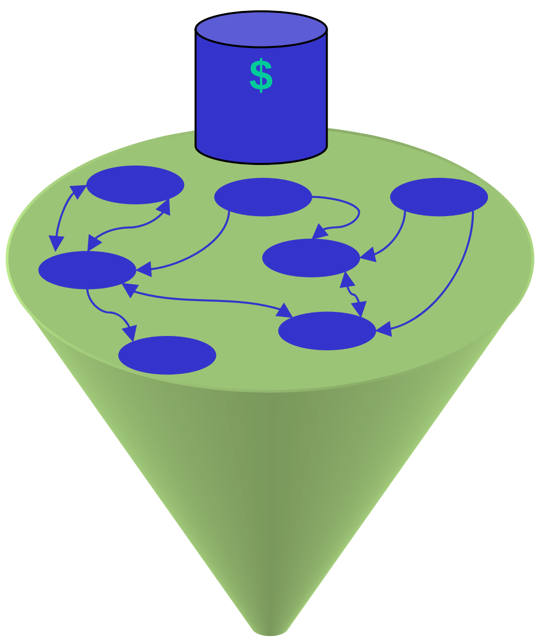
- Translating SoS capability objectives into high level requirements over time
- Understanding the systems in the SoS and their relationships
- Assessing extent to which the SoS meets capability objectives over time
- Developing, evolving and maintaining a design for the SoS
- Anticipating and assessing impacts of potential changes on SoS performance
- Evaluating new and evolving requirements on SoS and options for addressing these
- Orchestrating upgrades to SoS

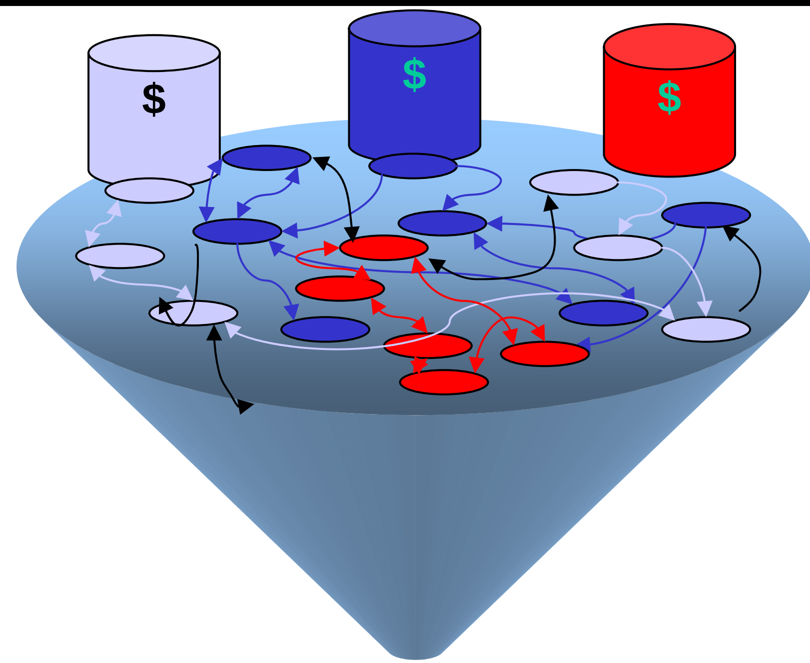
The SoS SE is responsible for creation and continual application of approaches to accomplish these elements

DoD SE Community

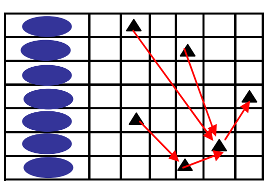
- **Ensure the DoD SE community is equipped to support war fighting capabilities at the system, system of systems, and enterprise levels by**
  - **Understanding the nature of the current and emerging development environments and the challenges they pose for SE**
  - **Identifying best practices in conduct of SE in supporting development and acquisition**
  - **Providing enabling policy, guidance, education and training**

System of Systems – The Management Challenge

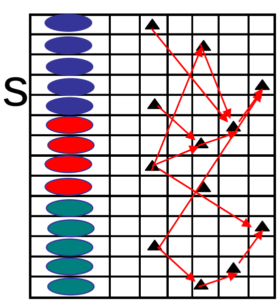




<u>SoS:</u>
Within
Single
Organization



<u>Joint SoS:</u>
Interdependencies
Across
Multiple
Organizations



Political and Cost Considerations Impact on Technical Issues

SoS Characteristics Which Impact Testing

- Difficulty in creating measurable SoS objectives
- Continued independent ownership of requirements and development of the component systems
- Variable component system contexts
- Asynchronous nature of the development processes across the SoS
- Size and variability in SoS membership and application domains
- Scale of the SoS
- Emergent behaviors

OTA Roundtable:
Applying
the
T&E Requirements Process
to
Unmanned / Autonomous Vehicles

Stephen C. Daly
Deputy Director, Operational Test & Evaluation for Land & Expeditionary Warfare
Office of the Secretary of Defense
Pentagon Room 1D548
(703) 697-3891
stephen.daly@osd.mil

Requirements

- Warfighters write requirements or “must have” capabilities – not testers, not evaluators.
- Warfighters define the concept of operations – not testers, not evaluators.
- Program Managers, testers, evaluators need to understand the **RATIONALE** behind the warfighter’s requirements and the warfighter’s CONOPS.
  - PM: where to trade cost, schedule, and performance.
  - Tester: structure tests to demonstrate system & unit performance.
  - Evaluator:
    - Assess unit mission accomplishment.
    - Assess system performance.
    - Answer the “so-what” question.

Comprehensive Testing

- Works in a well-known process to demonstrate system performance in a "model-test-fix-test" methodology.
  - Developmental Test & Evaluation.
  - Live Fire Test & Evaluation.
  - Operational Test & Evaluation.
  - Evaluation of the significance of system performance & unit mission accomplishment performance.

- Comprehensive T&E characterized by some as:
  - "Too slow."
  - "Too costly."
  - "You don't understand that my UAS/UAV is special."
  - "We're at war for gosh sakes."

DOT&E Point of View

- Many past systems started as Advanced Concept Technology Demonstration (ACTD).
  - Execution of ACTD's often skimps on the <u>demonstration</u>.
  - Often fail to address operational suitability issues.
  - Often has a cumbersome transition to a program-of-record.

- Common theme is to avoid government test in any form.

- In IOT&E:
  - Some UASs have been assessed as operationally effective.
  - To date, none have been assessed as operationally suitable.
  - Services have applied lessons learned and corrections to improve these systems since IOT&E.
  - <u>Lessons apply to other Unmanned Systems in development</u>.

Shadow IOTE in 2002 at Fort Hood

- Operationally effective under fair weather conditions and in the absence of an air threat for cued reconnaissance and surveillance missions … not operationally effective to target acquisition missions.
  - 57% of Recon-Surveillance reports were timely and accurate.
  - Demonstrated target location error in excess of 200 m (80 m req'd).
- Not operationally suitable.
  - Not reliable, not maintainable, 2 AV crashes and 1 significant damage.
  - Operational Availability meets user requirements due to redundancy.
  - Demonstrated ability to meet the Commander's operational tempo.
- Not survivable.
  - Susceptibility to detection is high.
  - Seen and heard within effective ranges of many threats.
  - Significant electromagnetic vulnerability.

Predator IOTE in 2000

- Predator is not operationally effective or suitable.
  - Disparity between the apparently successful fielded system and the systems that did not perform well in IOT is largely attributable to the fact that the system is tasked and operated well within known limitations such as effective time-on-station, weather restrictions, expected threats, expected accuracy, and dissemination abilities.
  - Capable of surveillance, recon, & battle damage assessment missions.
  - Poor Target Location Error (TLE), weather restrictions, and ineffective communication impact strike support, CSAR, area search, and continuous coverage.
  - Cannot meet requirements outlined in the ORD & KPPs.
  - Lack of relief-on-station procedures and poor reliability renders the system unable to meet the 75% Effective Time-on-Station (ETOS) requirement at range of 400 nm.
  - Serious deficiencies in reliability, maintainability, and human factors.

Raven IOTE in 2006 at Fort Bliss

- Raven SUAS is operationally effective.
  - Infantry company commander benefits from enhanced situational awareness and more operational planning options.
  - Used effectively in lieu of manned reconnaissance.
  - Can recognize manned-sized objects, but cannot identify armed from unarmed personnel or find IEDs.
  - AV susceptible to acoustic and visual detection.
- Raven SUAS is not operationally suitable.
  - SUAS-equipped unit cannot sustain itself in prolonged combat.
  - Consumed parts at a rate in excess of the parts allocation.
  - Operators were able to quickly repair the AV if parts were on-hand.
  - AV was not reliable, demonstrated 5.6 hrs MTBSA (12 req’d).

Observations & Advice

- Focus on warfighter's mission accomplishment, CONOPS, and total life-cycle cost.
  - Understand the rationale behind the capabilities and KPPs.
  - Clearly define mission success.
- Reliability ….. Reliability ….. Reliability.
- Take advantage of inherent redundancy, balance vs workload.
- Some tactical UAS fielded without operators – additional duty.
- Target location error and resolution.
- Weapons – create whole new set of additional operational issues.
- Work to reduce UAS susceptibility in early design efforts.
- System proliferation creates airspace management issues – will face similar terrestrial battlespace management issues.
- Extreme Environments – hot, cold, wind, weather.
- Countermeasures, GPS jamming, friendly Counter IED Systems – complex spectrum.
- Incorporate Real-Time Casualty Assessment System (RTCA).
- Warfighter's operate in a joint environment today.

Back-up Slides

10 USC Section 139

- "There is a Director of Operational Test and Evaluation in the Department of Defense, appointed from civilian life by the President, by and with the advice and consent of the Senate."

- "**Operational test and evaluation** means --
  - the field test, under realistic combat conditions, of any item of (or key component of) weapons, equipment, or munitions for use in combat by typical military users; and
  - the evaluation of the results of such test."

10 USC Section 139

“The **Director** shall --

- prescribe, by authority of the Secretary of Defense, policies and procedures for the conduct of operational test and evaluation in the Department of Defense;
- provide guidance to and consult with the Secretary of Defense and the Under Secretary of Defense for Acquisition and Technology and the Secretaries of the military departments in general and with respect to specific operational test and evaluation ...;
- coordinate operational testing conducted jointly by more than one military department or defense agency;
- monitor and review all operational test and evaluation in the Department of Defense;
- review and make recommendations to the Secretary of Defense on all budgetary and financial matters...;
- monitor and review the live fire testing activities of the Department....”

Operational Effectiveness

The <u>overall degree of mission accomplishment</u> of a system when used by representative personnel in the environment planned or expected for operational employment of the system considering:

- organization
- doctrine
- tactics
- survivability
- vulnerability
- threat

Operational Suitability

- The degree to which a system can be satisfactorily placed in field use, with consideration given to:
  - availability
  - compatibility
  - transportability
  - interoperability
  - reliability
  - wartime usage rates
  - maintainability
  - safety
  - human factors
  - manpower supportability
  - logistics supportability
  - documentation
  - training requirements

Hon. Charles E. McQueary
Director, Operational Test & Evaluation
703-697-3655

David W. Duma
Principal Deputy Director
703-697-4813
David.Duma@osd.mil
Missile Defense

Dr. Ernest Seglie
Science Advisor
Ernest.Seglie@osd.mil
703-697-3655

COL Bill Bennett
Senior Military Assistant
Henry.Bennett@osd.mil
703-697-3655

Stephen C. Daly
Deputy Director
Land & Expeditionary Warfare
703-697-3891
Steve.Daly@osd.mil

Land Warfare Systems
Expeditionary Warfare System
Future Combat Systems
Battle Command
Land Munitions
Rotary & Tilt-Rotor Aircraft
Tactical UAV
Chem-Bio Defense Program

Joint Rapid Acquisition Cell
Integrated Resource Analysis
T&E Threat Resource Activity
Joint Test Board

Michael D. Crisp
Deputy Director
Air Warfare
703-692-9929
Mike.Crisp@osd.mil

Air Combat Systems
Strategic Air Combat Systems
Aircraft Carriers
Air Launched Munitions
Endurance UAVs
Air Warfare C4ISR Systems
IR/UV/RF Def Combat Sys
Airlift Systems

Joint T&E Program
Center for Counter Measures

Thomas B. Blann
Deputy Director
Naval Warfare
703-681-5417
Thomas.Blann@osd.mil

Surface Ships
Submarines & UUVs
Navy Combat Systems
  Radars
  Sonars
  EW System
  CEC
Naval Munitions
  Missiles
  Guided Projectiles
  Torpedoes

William J. McCarthy
Deputy Director
Net-Centric & Space Systems
703-681-5411
William.McCarthy@osd.mil

Space & Strategic Systems
Net-Centric Systems
Strategic C4ISR Systems
Major Automated Info System
Chemical Weapons Demil

Network Information
  Assurance & Interoperability
  Assessment

Richard G. Sayre
Deputy Director
Live Fire
703-614-3991
Rick.Sayre@osd.mil

Live Fire – Land, Air, Naval
Lethality & Survivability

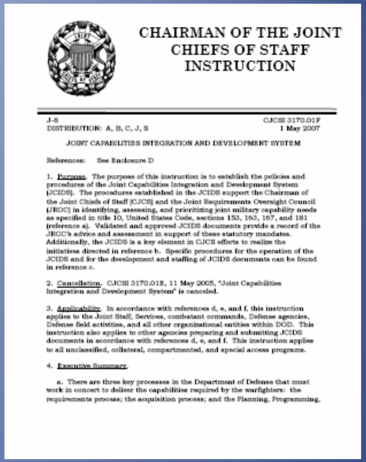
Joint IED Defeat
Joint Live Fire Program
Joint Aircraft Survivability
Joint Technical Coordinating
  Group-Munitions
  Effectiveness

Why have a Town Meeting on T&E role in Requirements Process?

- Address some of the following commonly heard questions and complaints*:
  - Requirements are too vague and/or confusing to test against.
  - Where did requirement X, Y, or Z come from?
    - Why "Speed X" versus "Speed Y"?
    - How does a specified capability impact the mission?
    - What happens to ability to accomplish the mission if the specified level of capability is not achieved?

* *There are probably others…*

Requirements Process



CHAIRMAN OF THE JOINT CHIEFS OF STAFF INSTRUCTION

J-8
DISTRIBUTION: A, B, C, J, S

CJCSI 3170.01F
1 May 2007

JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM

References: See Enclosure D

1. Purpose. The purpose of this instruction is to establish the policies and procedures of the Joint Capabilities Integration and Development System (JCIDS). The procedures established in the JCIDS support the Chairman of the Joint Chiefs of Staff (CJCS) and the Joint Requirements Oversight Council (JROC) in identifying, assessing, and prioritizing joint military capability needs as specified in title 10, United States Code, sections 153, 163, 167, and 181 (reference a). Validated and approved JCIDS documents provide a record of the JROC's advice and assessment in support of these statutory mandates. Additionally, the JCIDS is a key element in CJCS efforts to realize the initiatives directed in reference b. Specific procedures for the operation of the JCIDS and for the development and staffing of JCIDS documents can be found in reference c.

2. Cancellation. CJCSI 3170.01E, 11 May 2005, "Joint Capabilities Integration and Development System" is canceled.

3. Applicability. In accordance with references d, e, and f, this instruction applies to the Joint Staff, Services, combatant commands, Defense agencies, Defense field activities, and all other organizational entities within DOD. This instruction also applies to other agencies preparing and submitting JCIDS documents in accordance with references d, e, and f. This instruction applies to all unclassified, collateral, compartmented, and special access programs.

4. Executive Summary.

a. There are three key processes in the Department of Defense that must work in concert to deliver the capabilities required by the warfighters: the requirements process; the acquisition process; and the Planning, Programming,

- CJCSI 3170.1 Joint Capabilities Integration and Development System (JCIDS)

Why JCIDS?

- Support statutory requirements of JROC to validate and Prioritize Joint Warfighting Requirements.

- Primary Objective is to ensure the joint warfighter receives the capabilities required to successfully execute the missions assigned to them.

How does JCIDS work?

The JCIDS Process

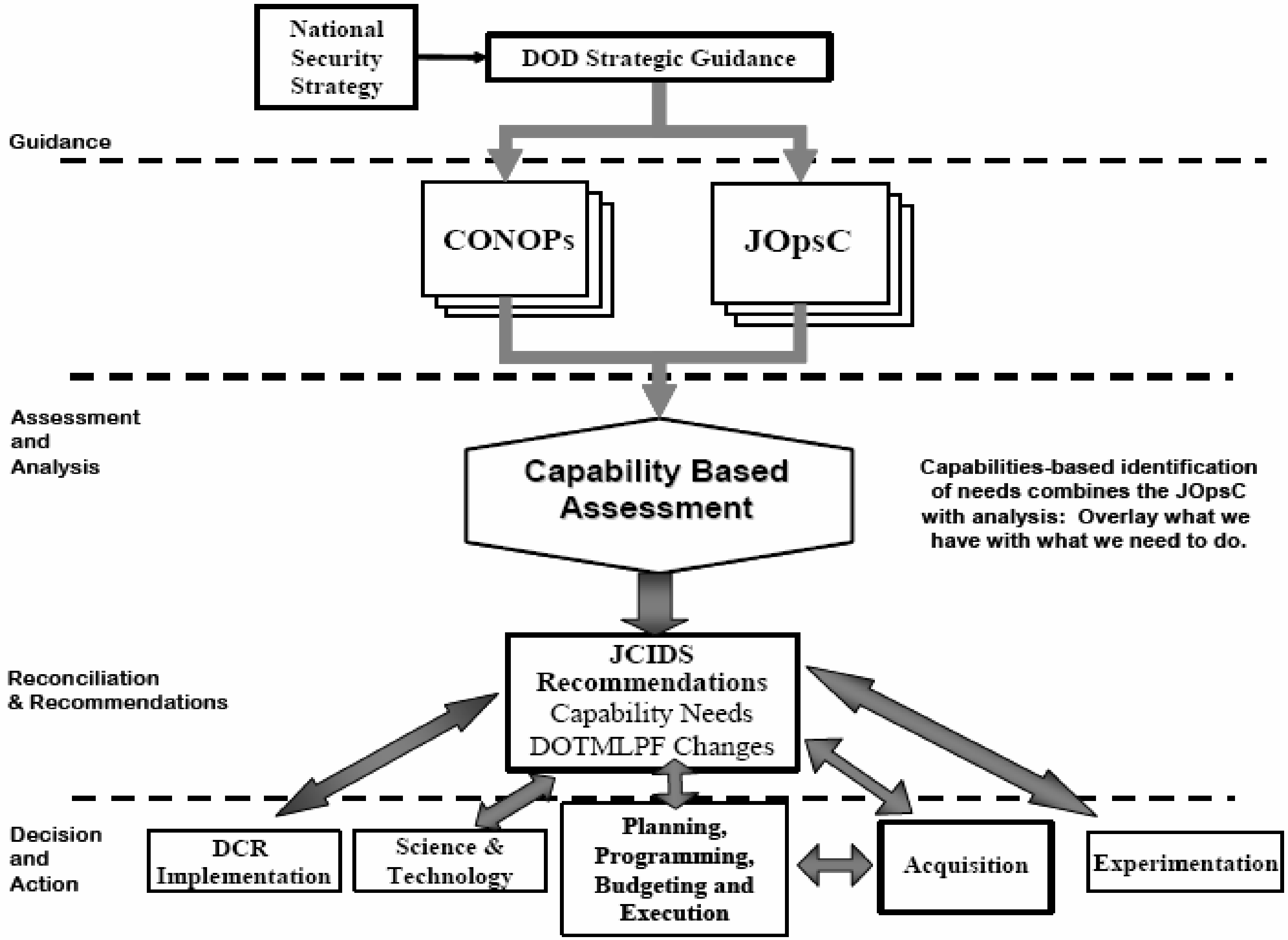
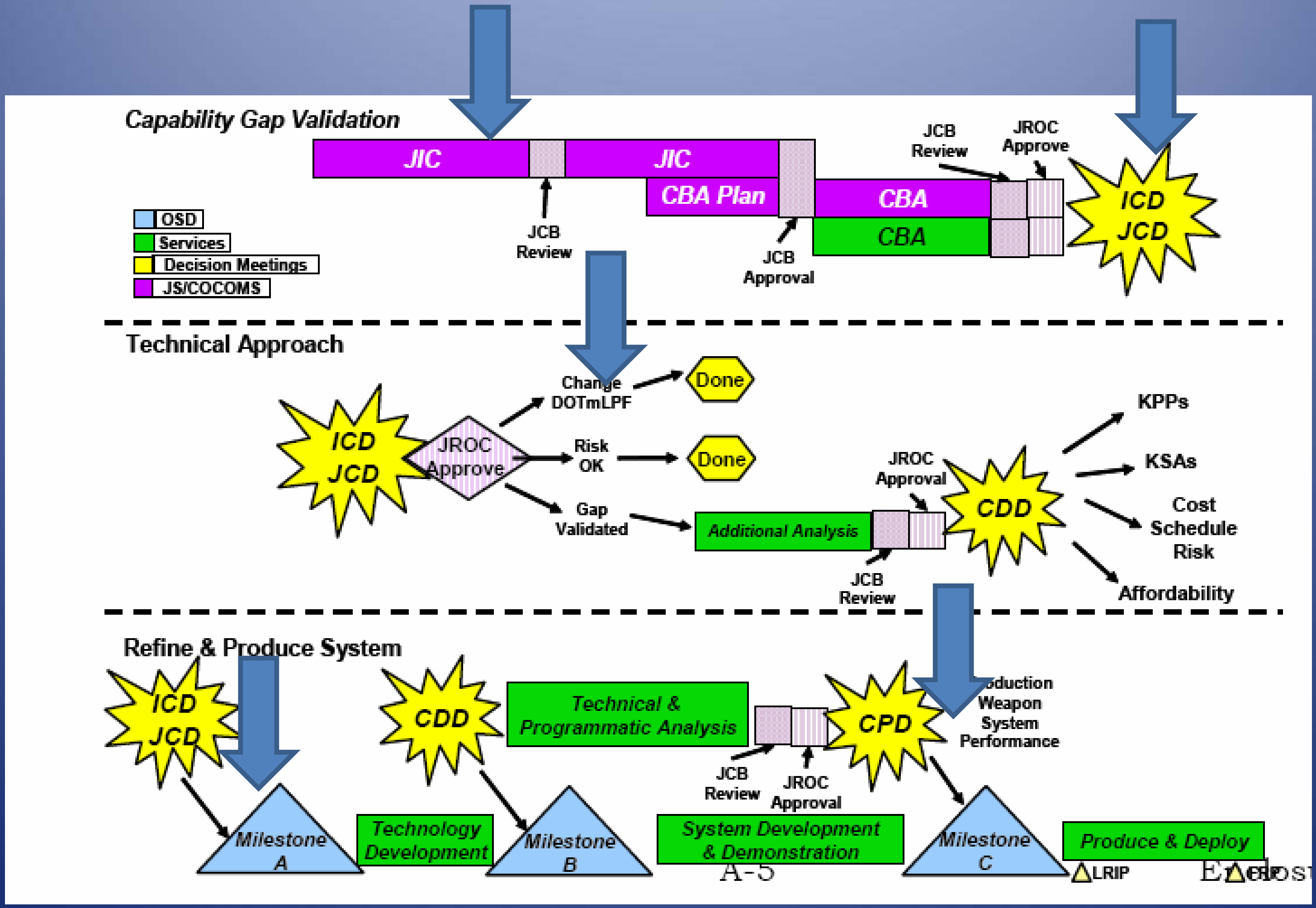


Figure A-1. Top Down Capability Need Identification Process

CJCSI 3170.1, dated 1 May 2007, page A-3

The JCIDS Process cont.

- Where does T&E fit in?



Where does T&E fit in?

- According to CJCSI 3170.1:

  JCIDS Documentation. The documentation developed during the JCIDS process provides the formal communication of capability gaps between the operator and the acquisition, test and evaluation, and resource management communities. The document formats and review processes specified in reference c are mandatory and shall be used throughout the DOD for all acquisition programs regardless of acquisition category (ACAT).

- Question – Where *should* T&E fit in the Requirements Development process?

Safety of Unmanned Systems

Sponsored by

Defense Safety Oversight Council Acquisition and Technology Programs Task Force (DSOC ATP TF)

Status Update

Mr. Michael H. Demmick

Agenda

- Leadership
- Background
- Objectives
- Approach
- Progress
- Organization
- Workgroup participants
- Precepts Review
- Final Product
- Summary

Unmanned Systems Leadership

- **OSD Sponsor**
  - **Mr. Mark Schaeffer, Director, Systems and Software Engineering & Chairman, DSOC ATP TF**
  - **Dr. Liz Rodriquez-Johnson, Executive Secretary, DSOC ATP TF**

Why Safety of UMSs?

MQ-1 PREDATOR WITH HELLFIRES (USAF)

Rapid Acquisition Pace Achievable

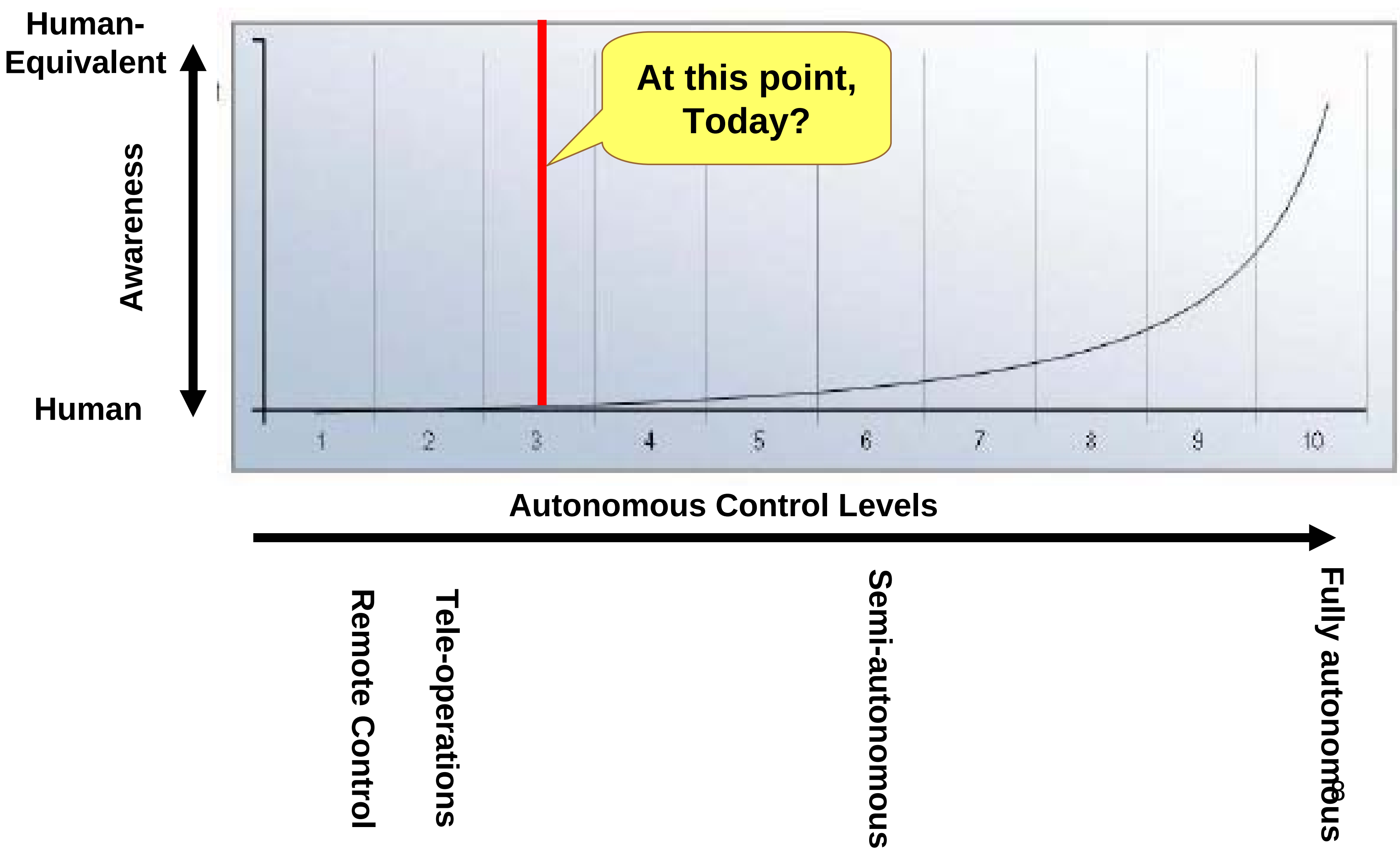
[redacted]

Talon Swords

UAV launch from MDARS

Raytheon UCAV

UMS Level of Awareness vs. Levels of Control



Background

- In FY05, the OSD Joint Robotics Program Coordinator for ground systems tasked Navy to:
  - Provide unifying safety guidance across all ground robotic projects
  - Establish initial safety precepts for ground robotic systems
    - Program Safety Guidance
    - Operational Guidance
    - System Design Safety Guidance
- Results briefed at 2005 ISSC

Background

- October 2005 briefed to OSD (DSOC ATP TF)
- ATP TF directed expansion of effort to include <u>all</u> Unmanned Systems (air, ground, and sea)
- Emphasized necessity of community input
  - Program Management
  - Design
  - Test
  - Operational
  - Safety
- Emphasized <u>guidance</u> vice direction

UMS Safety Objectives

- Focus the technical community on the System Safety needs for UMS
- Specifically:
  1. Understand the safety implications, including legal issues, associated with the rapid development and use of a diverse family of unmanned systems both within, and external to, the DoD.
  2. Establish and agree upon a standardized set of safety precepts to guide the design, operation, and programmatic oversight of all unmanned systems.
  3. Develop safety guidance, such as design features, hazard controls and mitigators, for the design, development, and acquisition of unmanned systems.

Approach

✓ **Involve technical community**
- – Six Workgroups
- – Approximately 80 technical experts
- – Government, Industry, Academia

✓ **Maximize Community Awareness**
- – March 2006 Workshop
  - • 300 attendees
- – International Systems Safety Conference (ISSC)
- – Association of Unmanned Vehicles International (AUVSI)
- – NDIA Systems Engineering Conference

✓ **Obtain Feedback**
- – Web Page (http://www.ih.navy.mil/unmannedsystems)
- – Tech Panels & Reviews

✓ ISSC (31 July - 4 Aug 2006)
✓ AUVSI (29 – 31 Aug 2006)
✓ NDIA Systems Engineering (23 – 26 Oct 2006)
✓ Mr. Schaeffer's Systems Engineering Forum
✓ NDIA Systems Engineering (22 – 25 Oct 2007)

Road to Completion

- ✓ **Held Three Workshops**
  - March 2006, Huntsville
  - May 2006, Crystal City
  - June 2006, Crystal City
- ✓ **Developed Safety Precepts**
  - Programmatic safety precepts (6)
  - Operational safety precepts (5)
  - Design safety precepts (19)
- ✓ **Developed more detailed design safety "best practices" (safety precept clarification tables) (ongoing)**
- ✓ **USD (AT&L) issued the Guide on 17 July 2007**

Workshop Organization

✓ **Six Workgroups**

1. **Precept Development**
2. **Weapons Control**
3. **Situational Awareness**
   - **Human-Machine Interface**
   - **Machine-Machine Interface**
4. **Command and Control**
5. **States and Modes**
6. **Definitions/Common Taxonomy**

Unmanned Systems Management Team

- **Members**
  - Mr. Dave Schulte
  - Mr. Ed Kratovil
  - Mr. Jim Gerber
  - Ms. Rhonda Barnes
  - Mr. Danny Brunson
  - Mr. Josh McNeil
  - Mr. Bill Pottratz
  - Dr. Tom English
  - Mr. Steve Mattern
  - Mr. John Canning
  - Mr. Bob Schmedake
  - Mr. Mike Demmick

Special Thanks
"Heavy Lifters"

- ✓ **Mr. Jim Gerber**
- ✓ **Mr. Mike Demmick**
- ✓ **Mr. Josh McNeil**
- ✓ **Ms. Rhonda Barnes**
- ✓ **Mr. Danny Brunson**

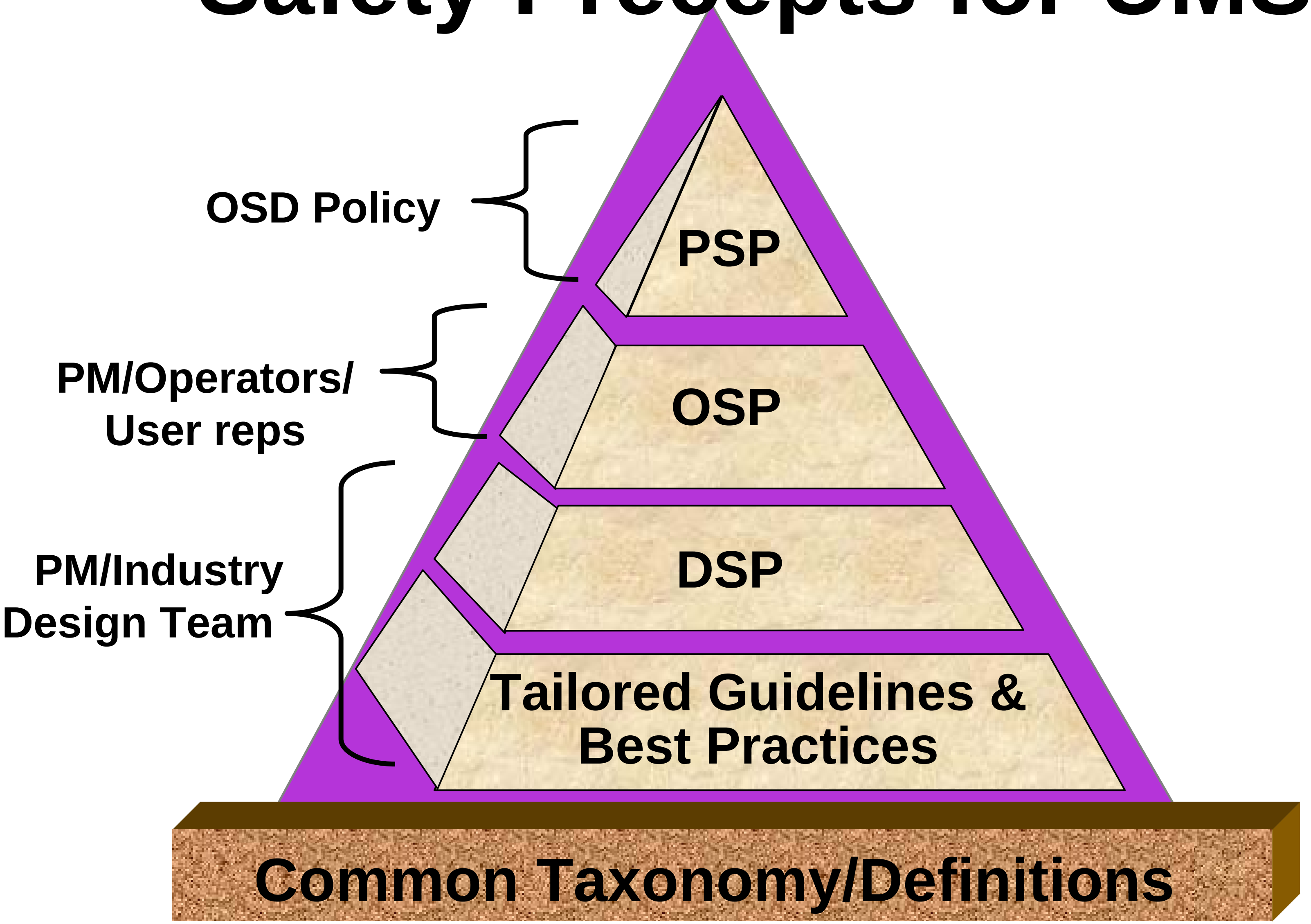
UMS Safety Precept Definitions

Programmatic Safety Precept (PSP) = **Program management principles & guidance that will help ensure safety is adequately addressed throughout the lifecycle process. (6)**

Operational Safety Precept (OSP) = **A safety precept directed specifically at system operation. Operational rules that must be adhered to during system operation. These safety precepts may generate the need for Design Safety Precepts. (5)**

Design Safety Precept (DSP) = **General design guidance intended to facilitate safety of the system and minimize hazards. Safety design precepts are intended to influence, but not dictate, specific design solutions. (19)**

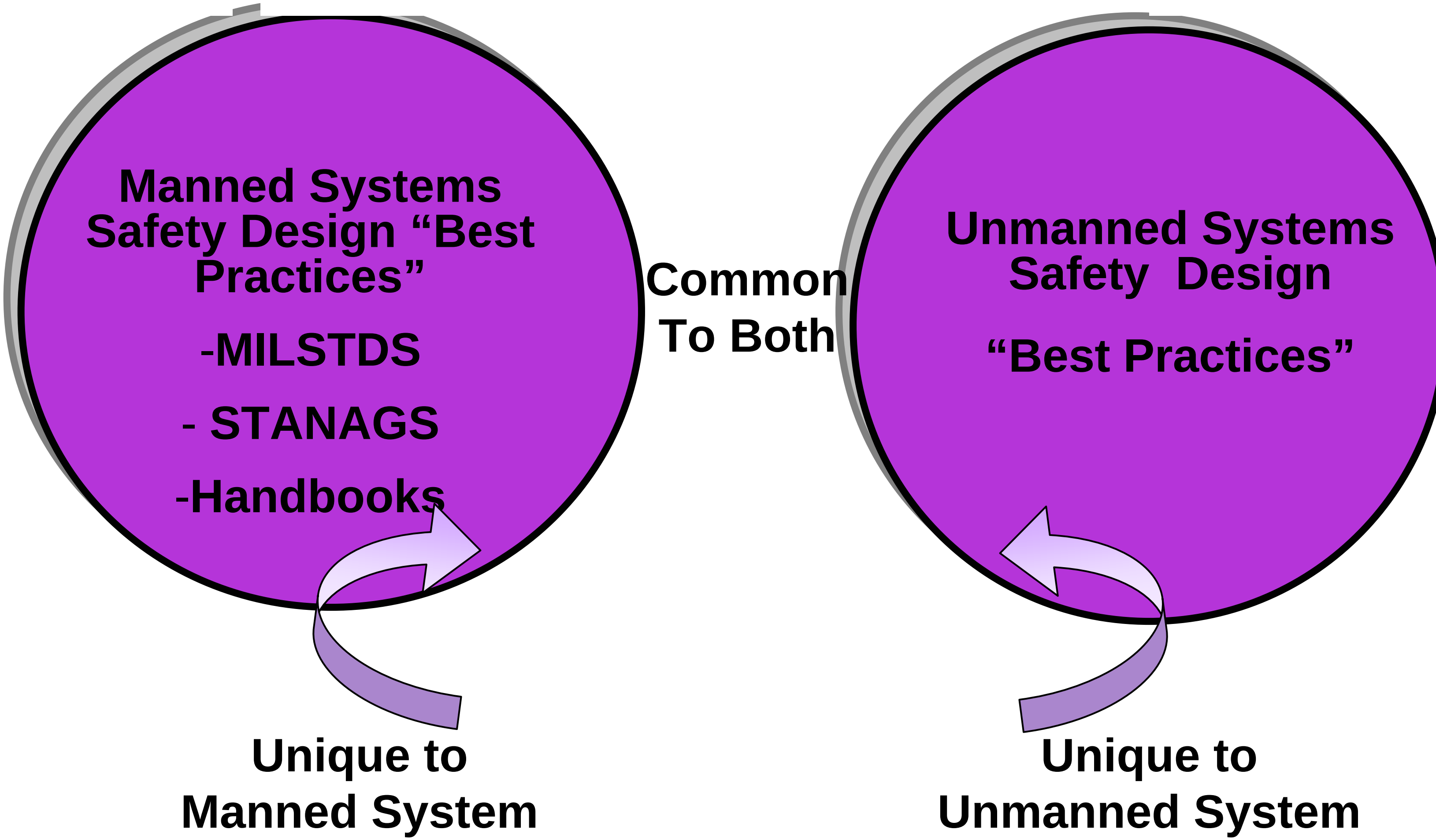
Safety Precepts for UMS



Provide PMs, designers, and systems safety managers with appropriate safety guidelines and best practices, <u>while maintaining PM's flexibility</u>

Safety Design Guidelines

**Are we creating two sets of safety criteria:
one for manned systems, and one for unmanned systems??**



Creating another set of safety requirements? No

Safety Precepts

- ✓ Did not previously exist
- ✓ Evolved through an arduous, but thorough, systems engineering process over the past 2 years
- ✓ Separate study was performed to determine if current DoD and/or Service-specific policies addressed each of the safety precepts

Safety Precepts (cont'd)

The results of this study indicate:

- ✓ **Safety precept PSP-1 is completely addressed in both DoD and Service-specific policies.**
- ✓ **Three precepts (PSP-4, PSP-6, and DSP-1) are completely addressed in DoD policy and are partially addressed in Service-specific policies.**
- ✓ **Four precepts (PSP-3, DSP-11, DSP-12, and DSP-19) are partially addressed in both DoD and Service-specific policies.**
- ✓ **Nine precepts (PSP-2, OSP-1, OSP-3, OSP-5, DSP-7, DSP-13, DSP-14, DSP-16, DSP-18) are not addressed in DoD policy but are partially addressed in Service-specific policy.**
- ✓ **Twelve precepts (PSP-5, OSP-2, OSP-4, DSP-2, DSP-4, DSP-5, DSP-6, DSP-8, DSP-9, DSP-10, DSP-15 and DSP-17) are not addressed in DoD nor Service-specific policies.**
- ✓ **One precept DSP-3 was not mapped to policy.**

Final Product

UNMANNED SYSTEMS SAFETY GUIDE FOR DOD ACQUISITION

27 June 2007

- ✓ **Document contains descriptive and clarifying text for each precept.**
- ✓ **Includes definitions**
- ✓ **But,…comments/lessons learned are still requested for future updates**
  - **NOSSA Website (http://www.ih.navy.mil/unmannedsystems)**

USD (AT&L) UMS Memo

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION, TECHNOLOGY AND LOGISTICS

JUL 17 2007

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
UNDER SECRETARIES OF DEFENSE
COMMANDERS OF THE COMBATANT COMMANDS
ASSISTANT SECRETARY OF DEFENSE (NETWORKS & INFORMATION INTEGRATION)
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING
DIRECTOR, OPERATIONAL TEST AND EVALUATION
DIRECTOR, PROGRAM ANALYSIS AND EVALUATION
DIRECTORS OF THE DEFENSE AGENCIES

SUBJECT: Unmanned Systems Safety Guidance

In March 2006, the Defense Safety Oversight Council Acquisition and Technology Programs Task Force (ATP TF) initiated a study to identify the unique safety challenges of unmanned systems (UMSs), especially those systems carrying and deploying weapons in a joint environment. These safety challenges significantly increase as more UMSs are fielded and used in the same warfighting environment.

Using a collaborative process with experienced personnel from all Services, the ATP TF developed the "Unmanned Systems Safety Guide for DoD Acquisition" to provide programmatic, operational, and design guidelines to support the development and fielding of safe UMSs. Please you use the Guide, found at http://www.acq.osd.mil/atptf/, to help identify and mitigate hazards and their associated risks for all UMS types.

For those UMSs that are ACAT 1D program, the UMS safety guidelines will be a special interest item during OSD Program Support Reviews. UMS-specific guidelines have been added to the Defense Acquisition Program Support methodology to guide the evaluation of how successfully programs have engineered UMSs to reduce safety risks to acceptable levels.

Kenneth J. Krieg

"… use the Guide to help identify and mitigate hazards and their associated risks for all UMS types."

Guidelines are a special interest item during OSD Program Support Reviews for ACAT ID UMS Programs.

Table of Contents

Programmatic Safety Precepts

PSP-1*: The Program Office shall establish and maintain a system safety program (SSP) consistent with MIL-STD-882.

PSP-2*: The Program Office shall establish unifying safety precepts and processes for all programs under their cognizance to ensure:

- **Safety consistent with mission requirements, cost and schedule**
- **Mishap risk is identified, mitigated and accepted.**
- **Each system can be safely used in a combined and joint environment**
- **That all safety regulations, laws, and requirements are met.**

PSP-3*: The Program Office shall ensure that off-the-shelf items (e.g., COTS, GOTS, NDI), re-use items, original use items, design changes, technology refresh, and technology upgrades (hardware and software) are assessed for safety, within the system.

Programmatic Safety Precepts
(Cont'd)

PSP-4*: The Program Office shall ensure that safety is addressed for all life cycle phases.

PSP-5: Compliance to and deviation from the safety precepts shall be addressed during all Milestone decisions and formal design reviews such as System Requirements Review (SRR), Preliminary Design Review (PDR), and Critical Design Review (CDR).

PSP-6*: The Program Office shall ensure UMS designs comply with current safety and performance criteria.

Note: While the document serves only as a guide, usage of the terms "shall" and "should" reflects the level of concern of the safety community

* Denotes applicability to both manned and unmanned systems.

Operational Safety Precepts

OSP-1: The controlling entity(ies) of the UMS should have adequate mission information to support safe operations.

OPS-2: The UMS shall be considered unsafe until a safe state can be verified.

OPS-3: The authorized entity(ies) of the UMS shall verify the state of the UMS, to ensure a safe state prior to performing any operations or tasks.

OSP-4*: The UMS weapons should be loaded and/or energized as late as possible in the operational sequence.

OSP-5*: Only authorized, qualified and trained personnel, with the commensurate skills and expertise using authorized procedures, shall operate or maintain the UMS.

Design Safety Precepts

DSP-1*: The UMS shall be designed to minimize the mishap risk during all life cycles phases.

DSP-2: The UMS shall be designed to only respond to fulfill valid commands from the authorized entity(s).

DSP-3: The UMS shall be designed to provide information, intelligence, and method of control (I2C) to support safe operations.

DSP-4*: The UMS shall be designed to isolate power until as late in the operational sequence as practical from items such as: a) Weapons, b) Rocket motor initiation circuits, c) Bomb release racks, or d) Propulsion systems.

DSP-5*: The UMS shall be designed to prevent release and/or firing of weapons into the UMS structure or other weapons.

DSP-6*: The UMS shall be designed to prevent uncommanded fire and/or release of weapons or propagation and/or radiation of hazardous energy.

DSP-7*: The UMS shall be designed to safely initialize in the intended state, safely and verifiably change modes and states, and prevent hazardous system mode combinations or transitions.

Design Safety Precepts
(Cont'd)

DSP-8*: The UMS shall be designed to provide for an authorized entity(s) to abort operations and return the system to a safe state, if possible.

DSP-9*: Safety critical software for the UMS design shall only include required and intended functionality.

DSP-10*: The UMS shall be designed to minimize single-point, common mode or common cause failures that result in high and/or serious risks.

DSP-11*: The UMS shall be designed to minimize the use of hazardous materials.

DSP-12*: The UMS shall be designed to minimize exposure of personnel, ordnance, and equipment to hazards generated by the UMS equipment.

DSP-13*: The UMS shall be designed to identify to the authorized entity(ies) the weapon being released or fired, but prior to weapon release or fire.

Design Safety Precepts
(Cont'd)

DSP-14*: In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.

DSP-15*: The firing of weapons systems shall require a minimum of two independent and unique validated messages in the proper sequence from the authorized entity(ies), each of which shall be generated as a consequence of separate authorized entity action. Both messages should not originate within the UMS launching platform.

DSP-16: The UMS shall be designed to provide contingencies in the event of safety critical failures or emergencies involving the UMS.

DSP-17: The UMS shall be designed to ensure safe recovery of the UMS.

DSP-18*: The UMS shall ensure compatibility with the test range environment to provide safety during test and evaluation.

DSP-19* The UMS shall be designed to safely operate within combined and joint operational environments.

Precept Clarification Table

Precept Number: Statement of the precept in the form of a requirement or general guidance.
Scope: Answers the question of “What?” the precept is for; often can be answered by “This precept addresses….”
Rationale: Answers the question of “Why?” the precept is required. This provides addition clarification of the intent of the precept.
Example: Provide as many clarifying explicit/real-world examples to demonstrate the issues and specific hazards the precept addresses.
Detailed Considerations: Answers the question of “How?” by providing details to assist with implementation of the precept. These are specific statements written in the form of a requirement or guideline which capture lessons learned and experience from other programs. Some of these considerations can be tailored for specific programs and incorporated into system specifications as safety requirements.

DSP-19 Combined Joint Operational Environments

DSP-19* **The UMS shall be designed to safely operate within combined and joint operational environments.**

Scope: The intent of this precept is to consider interoperability of the UMS with manned systems (unmanned undersea systems with ships, UAVs with manned military or commercial aircraft). This precept addresses de-confliction of air corridors and use of UMSs for non-military peace-time operations such as disaster relief and boarder patrol. This also addresses potential ad-hoc combinations of systems by the field commander(s) that may not have originally intended to operate as combined systems or as an SoS.

Rationale: The intent of this precept is to provide safety compatibility among independently developed systems operating in a combined or joint operational environment

DSP-19 Combined Joint Operational Environments (Cont'd)

DSP-19* **The UMS shall be designed to safely operate within combined and joint operational environments.**

Examples:

1. **Use of a UAV within the National Air Space (NAS).**
2. **Use of UMSs for non-military peace-time operations such as disaster relief and border patrol.**
3. **Multiple UMSs, operating in a net-centric environment, could tax the communications network bandwidth.**

DSP-19 Combined Joint Operational Environments (Cont'd)

DSP-19* **The UMS shall be designed to safely operate within combined and joint operational environments.**

Detailed Considerations:

- **Communication reliability, network availability/quality of service and data/information assurance shall be commensurate with the safety criticality of the functions supported.**
- **The system should be designed to be operated and transported during non-wartime conditions within normal transportation and commercial airspace environments meeting the requirements of the DOT, FAA, ETS 300-019, Part 1-2, IEC 721.**
- **Reference the Society of Automotive Engineers AS-4 Joint Architecture for Unmanned Systems (JAUS) Working Group related to interoperability.**
- **In accordance with CJCSI 3170 directives, all systems will be reviewed for safety within the joint, combined, and SoS environments.**
- **Reference NATO STANAG 4586 Section 1.1 (para 6).**

DSP-19 Combined Joint Operational Environments

DSP-19* **The UMS shall be designed to safely operate within combined and joint operational environments.**

Existing Policy:

Existing Policy:

Service	Document	Section	Comment
Joint Chiefs of Staff	DoD CJCSI 3170.01E		Text implies precept.
DoDD	4630.0544.1		Text implies precept.

Need your help in identifying any other existing policy documents

Summary

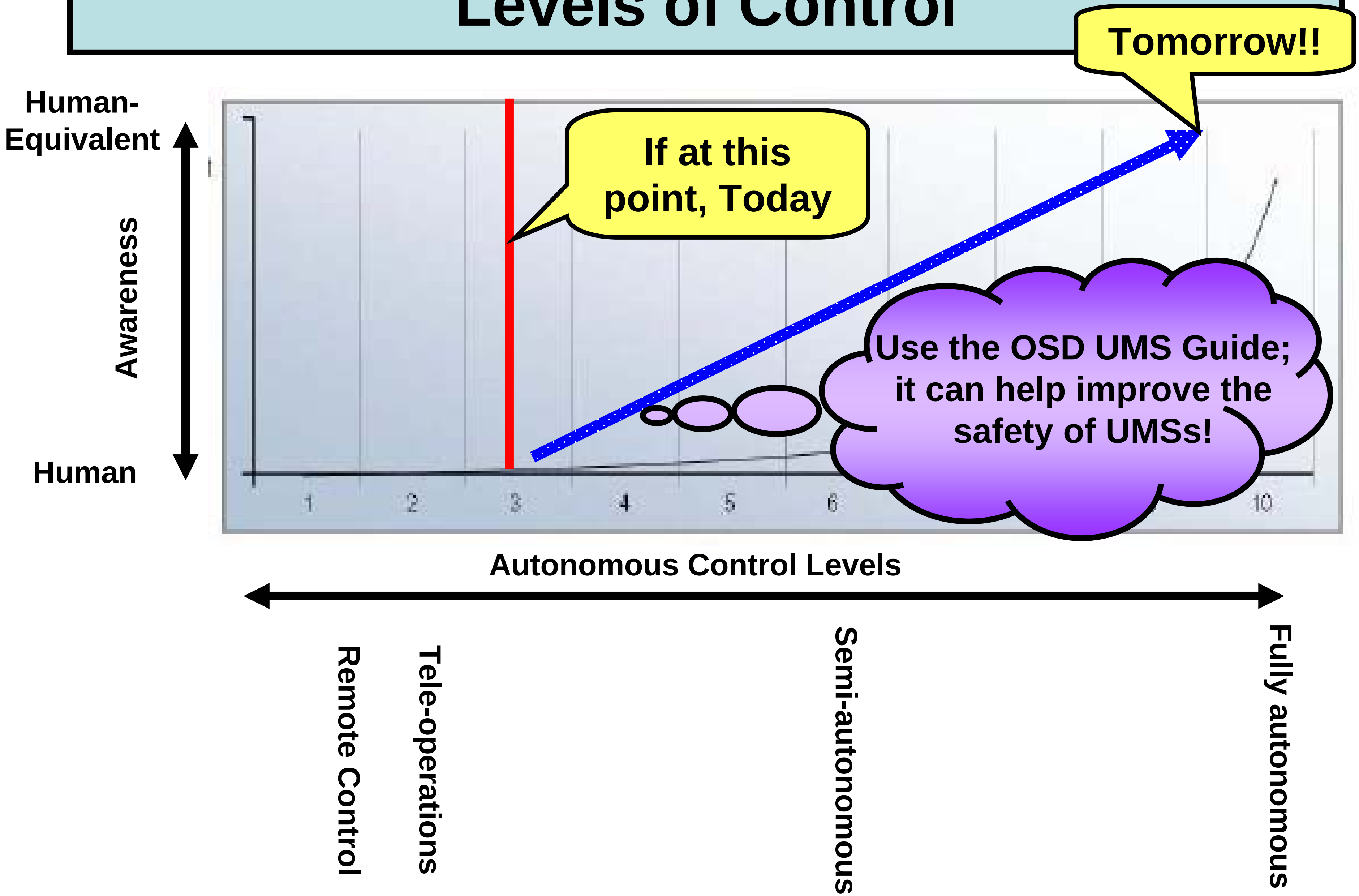
- ✓ Held three workshops (March, May, June 2006)
- ✓ Government/industry/academia teams developed draft safety precepts, rationale & design guidance
  - All Services and numerous UMS program office reps participating
- ✓ Developed Complex Programmatic, Operational, and Design safety precepts
- ✓ Briefed
  - International Systems Safety Conference (2005, 2006 and 2007)
  - AUVSI (August 2006)
  - NDIA Systems Engineering (October 2006 and 2007)
  - NDIA 24th Annual National Test & Evaluation Conference (February 2008)
- ✓ Comments Requested
  - NOSSA Website (http://www.ih.navy.mil/unmannedsystems)

Summary (cont'd)

USD (AT&L) Memorandum of 17 July 2007

- ✓ **Forwarded the Guide to the Service Secretaries and other major DoD components strongly endorsing it for all UMS acquisitions.**
- ✓ **Undersecretary directed that the UMS Safety precepts in the Guide be a special interest item for ACAT 1D Program Reviews.**
- ✓ **The Guide has been posted on the OSD ATP-TF Website at http://www.acq.osd.mil/atptf/**
- ✓ **Next steps:**
  - ➢ **Convert the Guide to a MIL-HDBK**
    - **Institutionalizes guidance, and facilitates Service ownership**
    - **Formatting complete; final Handbook estimated 3rd Qtr 2008**
  - ➢ **Update Policy and Service Directives to address UMS Precepts, where appropriate. (Remember, 12 Safety Precepts not addressed at all in policy.)**

UMS Level of Awareness vs. Levels of Control



[redacted]


Safety of Unmanned Systems
Sponsored by
DSOC ATP TF
Questions and Comments

Contact Information
ICO M. H. Demmick

- Name: Michael H. Demmick
- Phone: (301) 744-4932
- Company: Naval Ordnance Safety and Security Activity (NOSSA)
- E-Mail: Michael.Demmick@navy.mil

BACK-UP

Workgroup Participants

Precepts:

Mr. Josh McNeil (Army)

- Mr. Woody Eischens (OSD)
- Mr. Clif Ericson (EG&G)
- Mr. Tom Garrett (Navy)
- Mr. Hui-min Huang (NIST)
- Mr. Bob Jacob (Navy)
- Mr. Mike Logan (NASA)
- Mr. Ranjit Mann (APT)
- Mr. Jack Marett (Westar)
- Mr. Charles Muniak (LMCO)
- Ms. Kristen Norris (AOT)
- Mr. Alan Owens (Air Force)
- Mr. Scott Rideout (USMC)
- Ms. Peggy Rogers (Navy)
- Mr. Craig Schilder (APS)
- Mr. Arthur Tucker (SAIC)
- Mr. Frank Zalegowski (Navy)
- Mr. Jim Zidzik (Navy)
- Mr. Don Zrebieck (Navy)

Weapons Control:

Mr. Bill Pottratz (Army)

- Mr. Scott Allred (USMC)
- Mr. Bill Blake (ATK)
- Dr. Craig Bredin (Westar)
- Ms. Mary Ellen Caro (Navy)
- Mr. John Deep (USAF)
- Mr. Jon Derickson (BAE)
- Mr. John Filo (Navy)
- Mr. Mark Handrop (USAF)
- Mr. Chris Janow (Army)
- LTCOL Emil Kabban (USAF)
- Mr. Dave Magidson (Army)
- Mr. Chris Olson (APT)
- Mr. Preston Parker (USAF)
- Mr. Jack Waller (Navy)
- Mr. Mike Zecca (Army)

Workgroup Participants

Situational Awareness:

Dr. Tom English (Navy)

- Dr. Julie Adams (Vanderbilt University)
- Ms. Alicia Adams-Craig (Army)
- Mr. Brad Cobb (Navy)
- Mr. Mike Demmick (Navy)
- Mr. Travis Hogan (GVI)
- Mr. Hui-Min Huang (NIST)
- Mr. Frank Marotta (Army)
- Mr. Aaron Mosher (Boeing)
- Mr. Mike Pessoney (APT)
- Mr. Owen Seely (Navy)
- Mr. Hoi Tong (Foster Miller)
- Mr. Bill Transue (EOD)
- Dr. Anthony Tvaryanas (USAF)
- Mr. Alan Weeks (iRobot)

Command and Control:

Mr. Steve Mattern (Apogen Technologies)

- Mr. Frank Albert (Navy)
- Mr. Billy Arnold (General Dynamics)
- Mr. John Canning (Navy)
- Mr. Steve Castelin (Navy
- Mr. Michael Dunn (Army)
- Ms. Rachael Fabyanic (Navy)
- Mr. Eugene Gonzales (Navy)
- Ms. Martha Meek (Army)
- Mr. Helmut Portmann (Navy)
- Mr. Ron Price (Army)
- Mr. Ed Spratt (Navy)
- Mr. Mike Zemore (Navy)

Workgroup Participants

States and Modes:

Mr. Bob Schmedake (Boeing)

- Mr. Mike Brown (EG&G)
- Mr. Danny Brunson (EG&G)
- Mr. Jim Butler (L3)
- Mr. Bill Edmonds (Army)
- Ms. Melissa Emery (APT)
- Mr. Bart Fay (Westar)
- Mr. Steve Hosner (Titan)
- Mr. Bob McAllister (USAF)
- Mr. Lynece Pfledderer (LMCO)
- Mr. Henry Zarzycki (Army)

Definitions/Common Taxonomy:

Mr. Danny Brunson (EG&G)

- Mr. Scottie Allred (USMC)
- Ms. Mary Ellen Caro (Navy)
- Mr. Bill Christian (APT)
- Mr. Brad Cobb (Navy)
- Mr. Clif Ericson (EG&G)
- Mr. Ranjit Mann (APT)
- Mr. Steve Mattern (Apogen Technologies)

DSP-14 Loss of Command Link

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Scope: **This precept addresses the overall UMS design architecture and states and mode management in the event of unexpected loss or corruption of the command, control, and communications link (i.e. loss of data link, loss of command and control). The objective is for the UMS to be in the anticipated/expected state when recovery occurs. It is not the intended communication loss as in the case of underwater vessels or other fully autonomous UMS. The system should have the capability of storing a set of actions to take, or states to transition to, when the command link is lost. Predetermined means we have them in the plan. Expected means we intend that portion of the plan to go into effect for this condition. It applies to both the test and perational environments. This precept is related to DSP-3 and DSP-16.**

Rationale: **The intent of this precept is to assure that, by design; the controlling entity can anticipate the status, mode and state of the UMS, and any on-board weapons during a loss of link period, corruption of link, and the subsequent recovery of link. Determination of pre-determined and expected status should be based on analysis of such things as CONOPS, mission profile, and threat hazard assessments.**

DSP-14 Loss of Command Link (cont'd)

DSP-14* In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.

Examples:

1. A UAV would continue to fly out of range upon loss of command link if no contingency provisions are designed into the system.

2. A UAV has been directed upon loss of link to return to base. It currently has mission parameters loaded, weapons have been energized, and commanded to fire when communications link has been lost. The UAV responds to its mission parameters and is returning to base when it re-establishes communications….what state are the weapons in? Will it now execute its command to fire? If communications are lost and re-established, the UAV and weapons should default to an expected state.

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Detailed Considerations:

- **The design should define state and mode transitions, including a desired and/or predictable course of action (such as move physically to a safe zone or crash in a safe zone), in the event of loss of link or intermittent command and control. The criteria for pre-determined and expected states and modes, and the courses of action include:**
  - **the UMS CONOPS and application;**
  - **the level of autonomy and level of control;**
  - **the operating environment (i.e. training, test, underwater, airborne, etc.);**
  - **the adequacy of communication link.**

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Detailed Considerations: (cont'd)

The UMS design should consider retention of pertinent mission information (such as last known state and configuration, etc.) for the UMS and the controlling entity(ies) to recover from loss of the communications link.

- **The UMS design must consider limiting the duration for which undelivered messages are considered valid.**
- **The UMS design must consider undelivered messages that can exist within the communication system.**
- **The UMS should ensure command messages are prioritized and processed in the correct sequence and in the intended state and mode.**
- **Reference NATO STANAG 4404 Section 7.4 and 8.3. DoD 8500.1 Section 4.1; and DoD 5000.1 Section E1.1.9.**

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Existing Policy:

Service	Document	Section	Comment
Navy	NAVSEA SWO20-AH-SAF-10	Section 14.8.3	Text partially references precept.

Need your help in identifying any other existing policy documents

Time Space Position Information T&E Instrumentation Technology Investment Plan

"Ensuring T&E Ranges Can Meet the Test Requirements of the Future"

By

Mr. Dick Dickson

GPS Based Range Instrumentation and Equipment IPT Lead

TYBRIN Corporation

Presented at
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
National Test & Evaluation Conference

February 2008
Palm Springs, CA

Background

- The Time Space Position Information (TSPI) T&E Instrumentation Technology Investment Plan.
- A Defense Test Resources Management Center (DTRMC) initiative within the Central Test and Evaluation Investment Program (CTEIP).
  - Started as a GPS TSPI Technology Investment Plan several years back.
- Tri-Service test ranges provided a significant amount of data that has been compiled regarding current TSPI capabilities versus projected requirements.
- Several “Common Test & Training Range Architecture” (CTTRA) Workshops were conducted with government and private industry to collect information as well.

Background

- A draft document titled - "*TSPI Capabilities Survey, Needs Assessment and Preliminary Gap Analysis*" was produced with the data.
  - The objective was to identify current TSPI capabilities at the Major Range Test and Facility Base (MRTFB) facilities versus emerging TSPI needs.
  - Capture the deltas between current capabilities and emerging requirements.
  - Provide some insight into emerging technologies that could potentially bridge the gap.
- In essence, provide a roadmap for future CTEIP investment programs involving (originally) GPS TSPI instrumentation.

Background

- CTEIP determined there were significant gaps and holes in the data collected after reviewing the TSPI Technology Investment Plan (TSPI TIP).
- The Range Commanders Council's (RCC) Electronic Trajectory Measurement Group (ETMG) was approached to review and update the TSPI TIP.
    - Identify the holes in the current TSPI capabilities section and finish filling them in.
    - Scrub the emerging requirements and update them.
    - Update and validate the gap analysis between current TSPI capabilities versus future TSPI requirements.
    - Identify emerging technologies that could potentially be used to bridge the gap.

Initial Evaluation

- An analysis of the TSPI TIP determined:
  - The TIP spent a considerable amount of effort analyzing and documenting all TSPI capabilities (radar, GPS, optics, acoustics, multilateration, etc.), not just GPS TSPI capabilities.
  - The ETMG felt the gap analysis focused on high level requirements that didn't really provide any useful level of detail.
  - It also utilized survey responses from the T&E community which are useful, but not always accurate.
    - Hard to know if the person filling out the survey was the person with the right knowledge base and background.
    - Filling out surveys tends to be low on everyone's priority list.
    - The predominant theme tended to lean toward obsolescence versus inability to meet "current" TSPI requirements.

TYBRIN
THE BEST GO BEYOND

TSPI TIP Update

- The ETMG asked these questions after reviewing the TSPI TIP:
  - How can we take what has been collected thus far and turn it into a useful tool for CTEIP?
  - With so much effort put into documenting all TSPI instrumentation's current capabilities, should the gap analysis focus on just GPS instrumentation shortfalls or should it focus on TSPI capability shortfalls in general regardless of the type of instrumentation involved?
  - How do we validate the future TSPI requirements in order to conduct a meaningful gap analysis of current capabilities versus future requirements?
  - Who really should be providing these future TSPI requirements – i.e. the MRTFB ranges, their customers, or a combination of both?
  - Should an attempt be made to identify emerging technology that could hold the potential to meeting the identified future requirements?

TSPI TIP Update

- The approach adopted to update the TSPI TIP included the following:
  - Start with filling in the holes in the MRTFB current TSPI capabilities section as well as identify the shortfalls in meeting current TSPI requirements from a “Range” perspective.
  - Don’t use surveys but rather contact the ranges either by phone or face to face, and talk to the owners/operators of the TSPI hardware.
  - Obtain a much more accurate inventory of current TSPI capabilities.
  - Talk to the test managers and get their perspective on whether or not they can meet their customers TSPI requirements of today.
  - Identify who their top 5-7 customers are today (more on this later!)
  - Get the range’s perspective on where they see TSPI requirements (for all the types of testing they do) headed over the next 5-10 years without tying it to specific instrumentation.

TSPI TIP Update

- Identify and document (to the extent possible) known and projected TSPI requirements 5-10 years from now.
  - Very tough to do!
  - Identify the types of TSPI required including performance expectations, types of data required, level of accuracy/resolution, real-time or post processed, regardless of the type of TSPI instrumentation that would potentially provide this data.
  - More on this later!
- Review current capabilities (all TSPI instrumentation) versus known or projected future TSPI requirements and conduct a gap analysis.
- Document shortfalls where possible (known or projected).

Identifying Emerging TSPI Requirements

- Considered to be the toughest challenge in updating the TSPI TIP.
- Identifying "real" hard requirements versus "I think this will be the requirements" or the notion of "If we build it, they will come" type of requirements is hard to do.
- Obtaining funding for new range instrumentation or upgrades to existing instrumentation is hard to come by.
- Approving a new I&M or CTEIP program based on the two reasons listed above is not going to fly.
- To the extent possible, we need documented requirements from range customers.
  - What systems will be tested at the MRTFB ranges 5-10 years from now?
  - What types of TSPI is going to be need and at what level of accuracy/resolution?

Identifying Emerging TSPI Requirements

- Problems faced in obtaining hard data on emerging TSPI requirements:
  - Obtaining input directly from the range test mangers and equipment operators is a key part of the process but not the only component.
    - Their perspective tends to be limited to what types of TSPI requirements they have today as well as looking at the progression of TSPI requirements over recent years in order to project future requirements.
  - The more important component in identifying future TSPI requirements has to come from the program offices, companies and vendors (i.e. range customers) that use the MRTFB ranges to conduct testing requiring TSPI data.

Identifying Emerging TSPI Requirements

- MRTBF range customers - government program offices, hardware manufactures, etc. hold the key to identifying future TSPI requirements.
  - We must find out from them what hardware, equipment, or systems they plan on bringing to our MRTFB ranges in the next 5-10 years to test.
  - We must identify their TSPI requirements in order to successfully test these systems.
- This can only be accomplished if we know what their test requirements are.
  - What are the performance specifications they have to test and validate?
  - What are the types of test scenarios they will employ?

Identifying Emerging TSPI Requirements

- Problems faced by many programs that use MRTBF ranges for testing:
  - They do not usually consider specific TSPI requirements they have early on in their programs.
  - They focus is on hardware and system development and identifying their own performance specifications.
  - Quite often very little thought is given to what kind of TSPI instrumentation and data they are going to need to validate their system performance until they get close to being ready to utilize a test range.
  - Many times, they do not have a good understanding of the TSPI capabilities available in order to determine if they can adequately test their system in the test scenarios that need to be conducted.

Documenting Emerging TSPI Requirements

- The ETMG will attempt to contact as many of the program offices and companies as possible after identifying the top 5-7 customers for each T&E range.
  - Discuss what they have on the drawing board (new systems, upgrades to existing systems, etc).
  - Determine what types of testing will they expect to conduct at the T&E ranges.
  - Identify the system performance requirements they will have to validate through testing such that we can back our way into what TSPI instrumentation will be required and the level of accuracy/resolution needed.
  - Where possible, have the various customers submit these requirements in writing.

Customer Understanding Of TSPI Capabilities

- The ETMG will discuss current TSPI capabilities with customers.
  - Try and determine what the customers' level of understanding is about TSPI capabilities at the ranges.
  - Educate them where needed on the current TSPI capabilities available and help them determine if what we have now is going to meet their requirements 5-10 years from now.
- But you may ask, if they are already T&E range customers, they should know what capabilities are there!
- Surprisingly this is not necessarily the case (e.g., Boeing)

Identify Emerging Technology

- The final phase of updating the TSPI TIP will be identifying emerging technology that holds the potential for meeting future TSPI requirements.
- This will be a high level look at emerging technology due to the time constraints for completing this document.
  - The ETMG feels that identifying and documenting future TSPI requirements and conducting a gap analysis is the most important part of this task.
- Current TSPI instrumentation capabilities and associated technology will be compared to emerging technology and recommendations will be provided on potential technology areas to explore in the future.

TYBRIN
THE BEST GO BEYOND

Summary

- The ETMG will update and validate the existing TSPI Capabilities Survey, Needs Assessment and Preliminary Gap Analysis.
- Update current existing TSPI instrumentation capabilities.
- Focus on identifying emerging TSPI requirements.
  - Obtain formal documentation on these new requirements when possible.
- Perform a gap analysis on existing TSPI capabilities versus future TSPI requirements.
- Update the TSPI Technology Investment Plan based on the gap analysis
- Provide CTEIP with a viable planning tool they can use for years to come.

2008 Annual NDIA International Symposium

Unique Challenges of Unmanned Air Systems (UASs) Test and Evaluation

Presented By:

RDML David Dunaway

Assistant Commander, Test and Evaluation, Naval Air Systems Command

Commander, Naval Air Warfare Center Weapons Division

david.dunaway@navy.mil

26 February 2008

Naval Air Systems Command

The Landscape

If we can find the target, we can kill the target

Increased cost = less stuff

Timely, multi-source , fused Intelligence is the key

Prolific demand and use
Increased cost

Unmanned Air Systems are a key enabler

Unique solutions
Decreased interoperability
Increased cost

Commercial supply and operational demand outpaced technical standards

No standards equates to unique solutions

Actionable information needs consistency and trust

Multiple additional requirements

Creates a huge spectrum of solutions

Why is it hard for UASs to fit in the Manned Aircraft T&E Community?

Manned Aircraft

100 years of refining processes and thinking

- Set communities
  - Strike
  - Rotary wing
  - Etc
- Standard Testing areas
  - Flying qualities
  - Mission systems
  - Propulsion
  - Etc

UASs

~15 years of rushing to field

- Components
  - Air Vehicles
  - Control Stations
  - Links
  - Sensors
- Types
  - Micro
  - Mini
  - Small
  - Tactical
  - Strategic

Lets make sure we don't try to fit a square peg in a round hole

UAS T&E Requirements

Manned aircraft T&E requirements well known

Frequencies | Performance | Support Systems | Safety

? ? ? ?

Largely Unknown

Across broad spectrum of UAS T&E

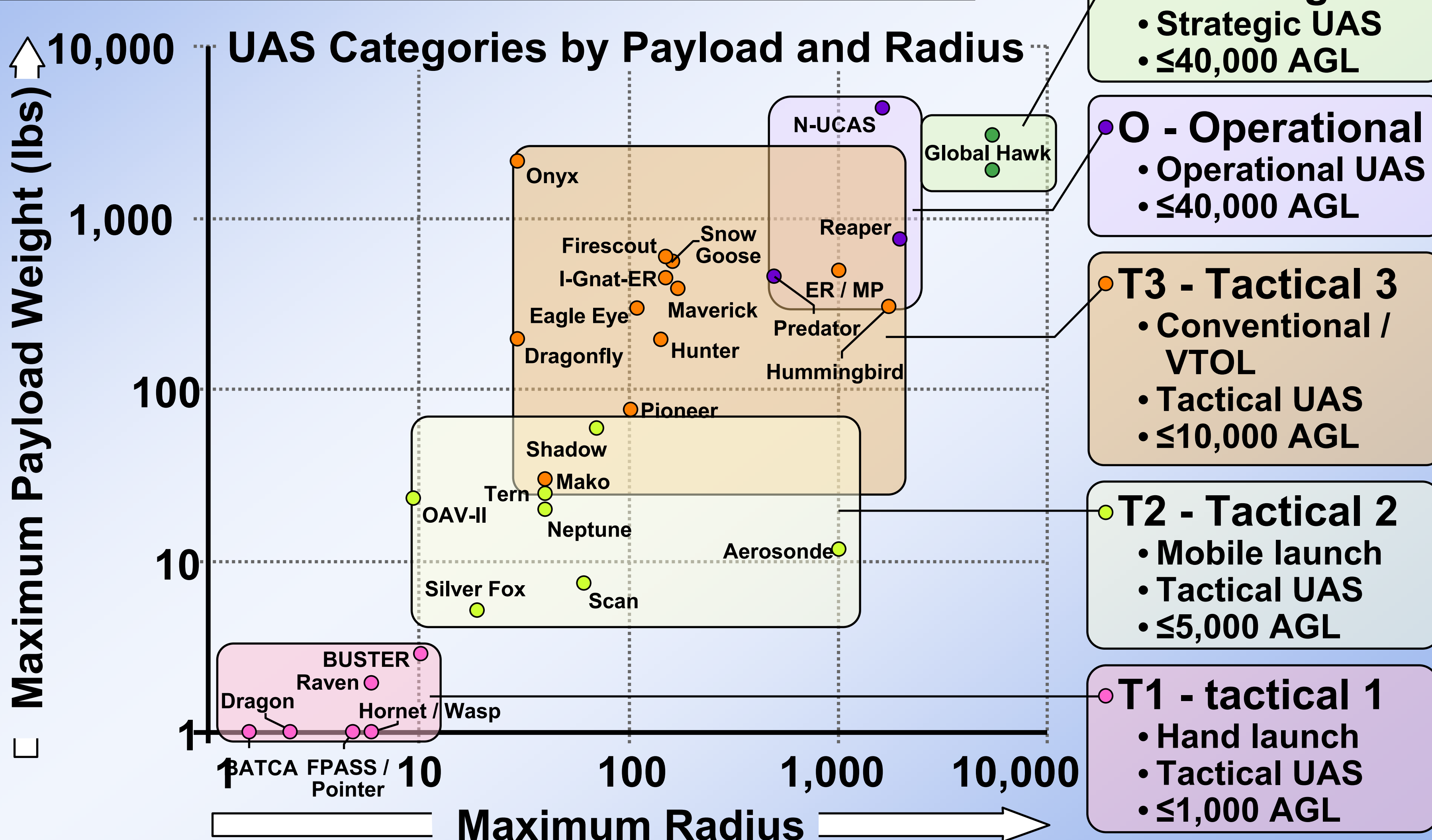
Raven
4-ft Wingspan

All Sizes, Capabilities, & Costs

Global Hawk
131-ft Wingspan

Broad Spectrum of Designs, Capabilities, & Missions

Wide variety of capabilities



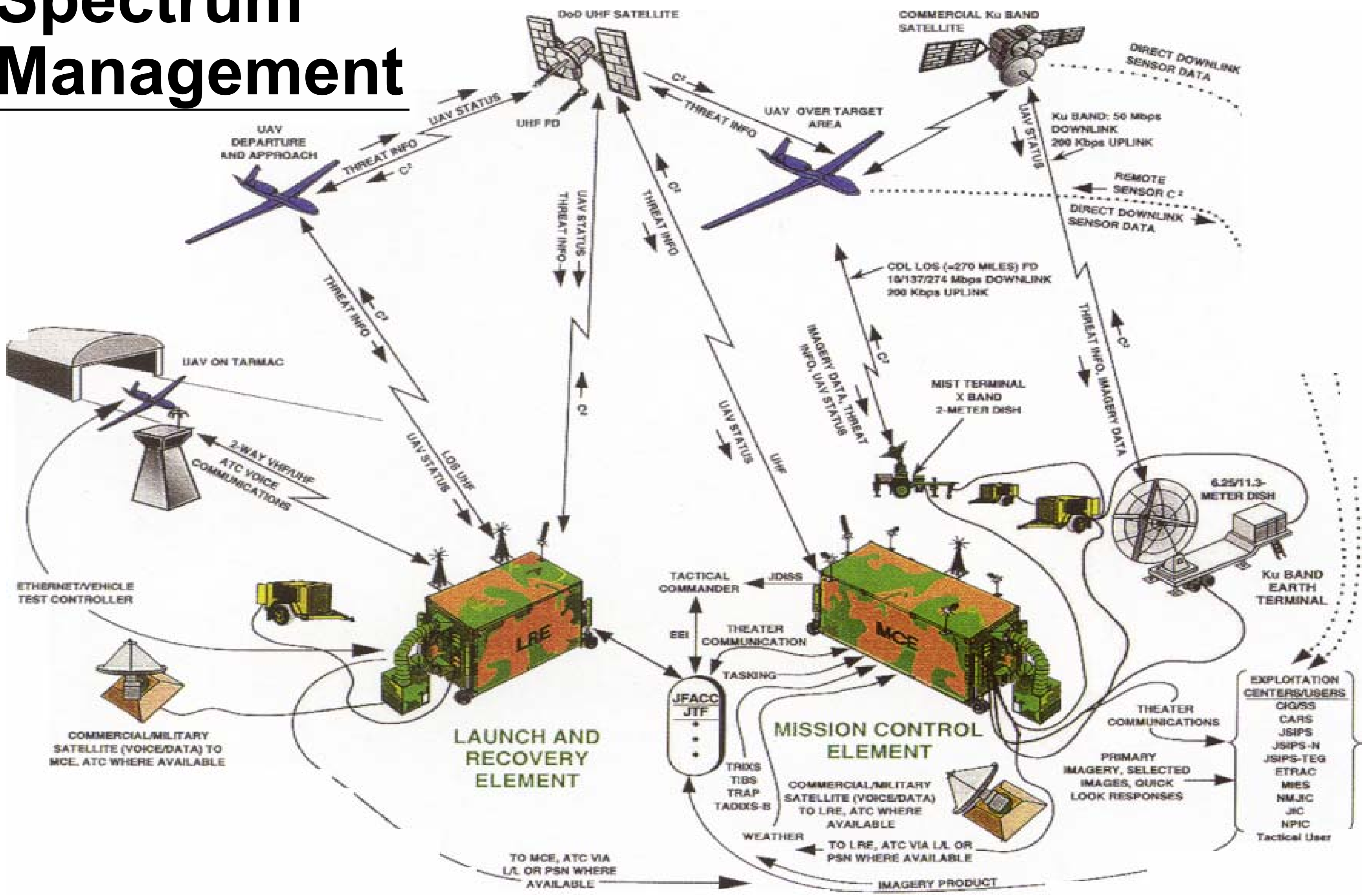
Note: BAMS is not shown as final threshold max payload and mission radius are still TBD

Technical Challenges

- **Wide variety of sizes, performance, capabilities, and costs**
- **Most hardware and software proprietary**
  - **Non-standard**
  - **Inhibits interoperability**
  - **Increases costs**
- **Airspace integration**
  - **Not designed to operate in National Airspace System (NAS)**
  - **Difficult to obtain Certificate of Airworthiness and FAA and DOD flight clearances**
  - **Lack of Identify Friend or Foe (IFF) and other standard equipment**

Technical Challenges

Spectrum Management



Range Challenges

Each System Has Different Scope of Requirements

Different:

- Concepts of Operations for interoperability and airspace integration
- Frequency de-confliction
- Encroachment
- Vast array of physical problems

Safety is a major driver

Social Challenges

- Different perceptions
  - Pilot off-board vs. onboard
  - Risk and consequences of UAS mishaps
  - Manned vs. unmanned testing standards
- Risk management
  - Commercial, Range, and Military operations differ
  - Attritable systems still have risk and impact
  - Trade-space differs from manned testing
  - Lost-link procedures

Successes

- H.R. 2881 FAA Reauthorization Act
- Integrated frequency de-confliction system
- Reallocation of 1400 MHz of new UAS flight test bands
- Adapting processes, facilities, and procedures
  - Updating Range Safety and Air Operations manuals
  - Better review and analysis of UAS technologies and capabilities
  - Increasing Use of M&S/ground test facilities

Successes

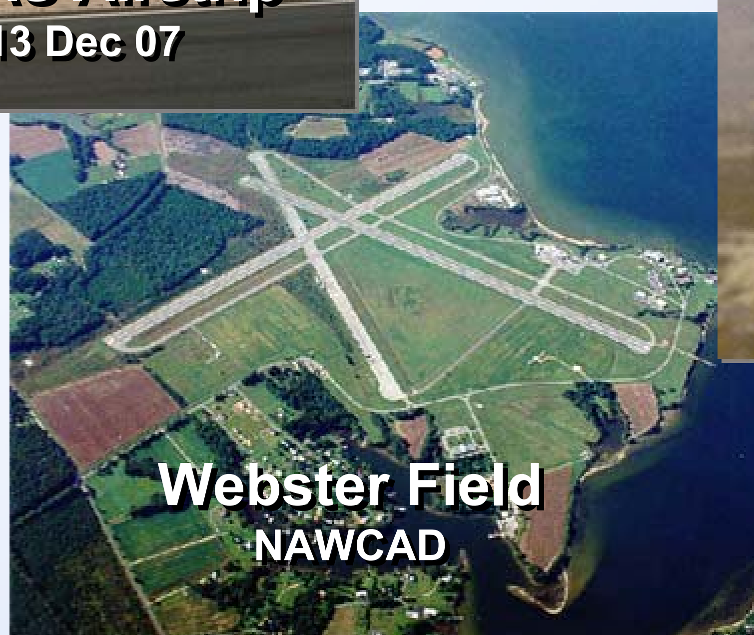
Successfully and safely integrated Global Hawk and manned aircraft operations

Mission Plan within R-4005/6/7/8 complex Patuxent River

Successes

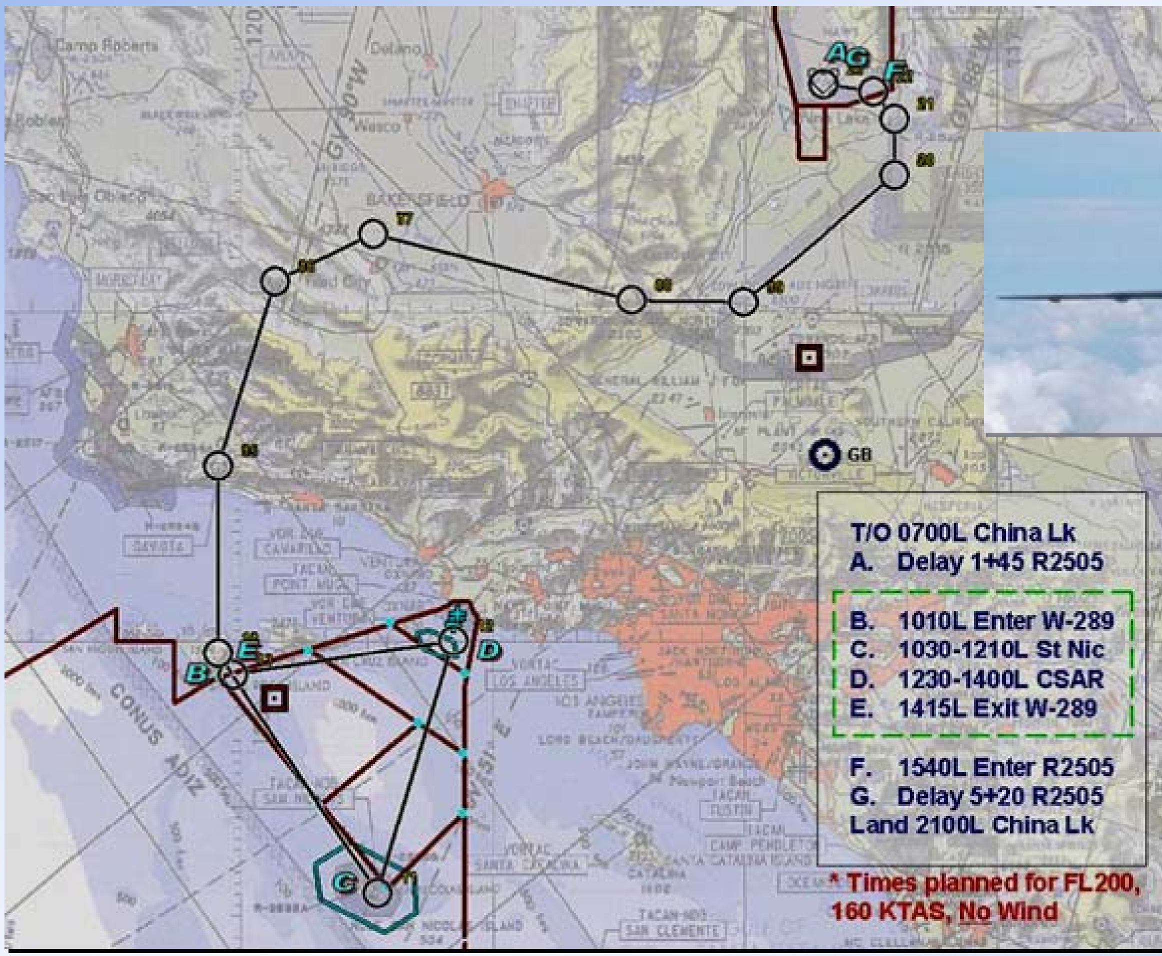
Expanded use of outlying airfields and Range Facilities

China Lake UAS Airstrip
Inauguration, 13 Dec 07



Webster Field
NAWCAD

Successes



Air routes are being established and exploited today

Flight Routing
China Lake to San Nicolas Island

Conclusions

- Broad spectrum of systems
  - Unique set of Technical, Range, and Social Challenges
- UAS Test & Operation not standardized
  - Doesn't always fit manned aviation construct
- Processes and infrastructure need to catch up
  - AirOps, Range Safety, airspace, communications, runways, hangars
- UASs represent great new potential
  - Many successes starting to leverage these capabilities

UASs are revolutionizing the way we prepare for and fight wars in the 21st Century

Improving Requirements & Testing Process for Rapidly Fielded Unmanned Aerial Systems

Jeremy Dusina

Juan Carlos Sanchez

Outline

- **Unmanned Aircraft Systems**
  - ATEC Mission Statement
  - Test & Evaluation challenges
  - Recommendations
  - Conclusions

ISSUE

Provide the warfighter adequately tested systems with robust evaluations in a timely manner to support Rapid fielding

ATEC Mission Statement

- Facilitate equipment procurement/fielding decisions through testing and analysis to ensure our Army’s Warfighters have the right capabilities for success across the entire spectrum of operations.
- Conduct rapid testing in direct support of the GWOT warfighter, providing capabilities and limitations analyses of weapon systems to enable employment decisions for rapid fielding to the Combat Soldier.

T&E Challenges – Rapid Fielding

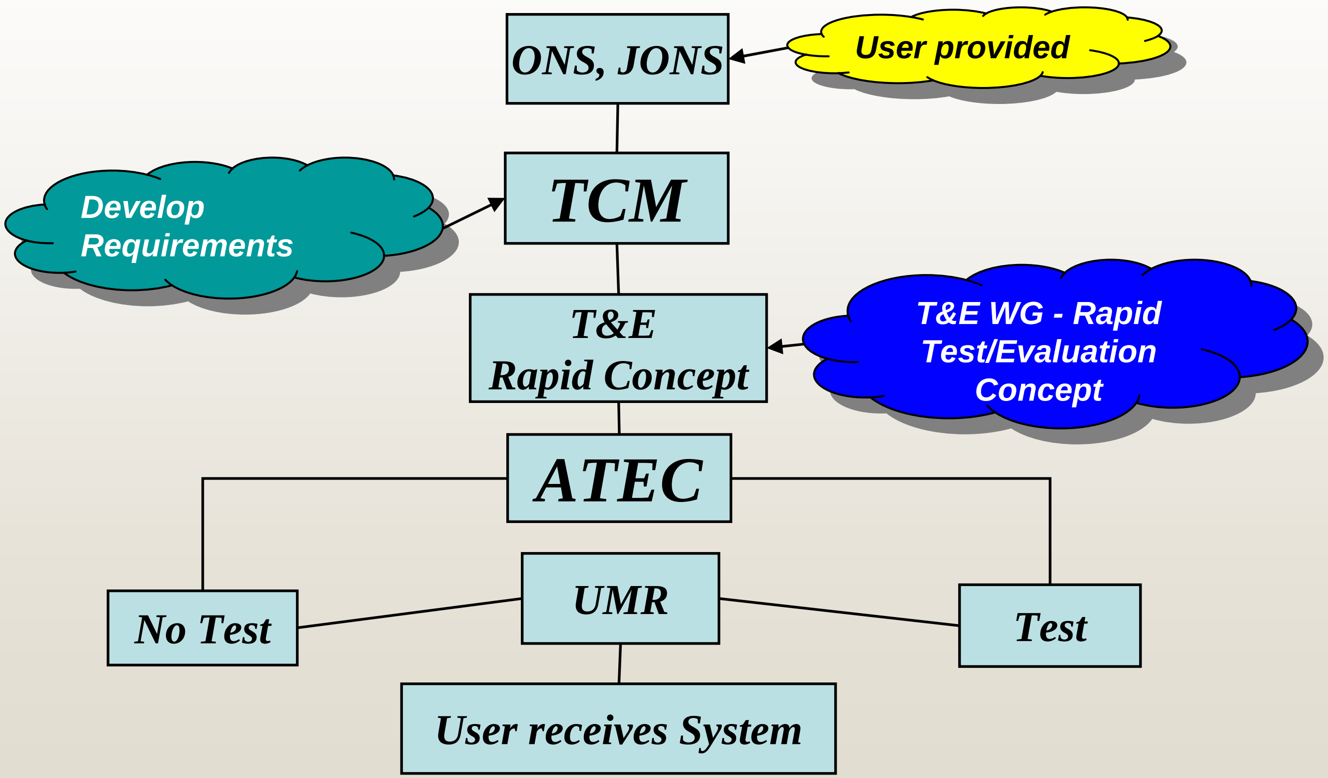
- ONS lack extensive operational requirements
  – Mission not defined until system is deployed
  – Many times, difficult to quantify
- Limited test schedule and scope:
  – Use prior test data when possible
  – Leverage existing training/exercises
- Warfighers want systems because they are ‘better than nothing’
  – Must still be tested to determine capabilities and limitations of the system
- No key denominator for UAS

T&E Challenges – Capabilities & Limitations

- Include aviation and infantry based requirements and operations
- Must develop a robust list of capabilities and limitations of the system for the Warfighter:
  - Provides the warfighter with the intended operating envelope/environment of the system
- Rapid systems provide users with added capability
  - Do not replace/improve existing equipment
- Minimal analysis has not provided the Army a clear picture of how best to employ UAS

Recommendations

- Simplified Rapid Acquisition Process
- Must have ***early*** TRADOC involvement with users/units, PM, and ATEC for rapid equipping



****TCM – TRADOC Capabilities Manager***

Conclusions

- UAS is a rapidly growing field within the Army
- OIF and OEF require systems to be fielded as quick as possible to support the warfighter
- Need for improved rapid acquisition process
- T&E Community will be able to support user with a system that will better meet mission needs
- Difficult to Quantify
  - Force Multiplier
  - Situational Awareness
- Does the Warfighter need all of these systems?
- What is the key denominator?

Contact Information

- Jeremy Dusina
  - ATEC-AEC-AVED
  - Comm: (703) 681-2729
  - DSN: 761-2729
  - BB: (571) 309-9873
  - Jeremy.Dusina@us.army.mil
- Juan Carlos Sanchez
  - ATEC-AEC-AVED
  - Comm: (703) 681-2733
  - DSN: 761-2733
  - JuanCarlos.Sanchez@us.army.mil

NORTHROP GRUMMAN

DEFINING THE FUTURE

Unmanned Systems: What's New, What's Not

Gene Fraser
Vice President and Deputy, Integrated Systems Western Region
Unmanned Systems Lead and Site Manager
Northrop Grumman Corporation

Northrop Grumman 2007 Sales

CHAIRMAN & CEO

Ron Sugar

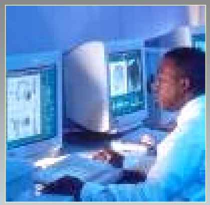
PRESIDENT & COO

Wes Bush

Northrop Grumman Corporation

Total Sales 2007: $32B*

OPERATING SECTORS

MISSION SYSTEMS	INFORMATION TECHNOLOGY	TECHNICAL SERVICES	ELECTRONIC SYSTEMS	INTEGRATED SYSTEMS	SPACE TECHNOLOGY	SHIPBUILDING
						
† Sales **$6.1B**	**$4.5B**	**$2.1B**	**$6.7B**	**$5.1B**	**$3.1B**	**$5.8B**
Command, Control and Intelligence	Enterprise Systems and Security	Systems Support	Radar Systems	Large Scale Systems Integration	ISR Satellite Systems	Naval Systems Integrator
Land Forces / Digitized Battlefield	IT/Network Outsourcing	Training and Simulations	C4ISR	C4ISR	Missile Defense Satellite Systems	Nuclear Aircraft Carriers
ICBM Systems Management	Defense & Intelligence	Life Cycle Optimization	Electronic Warfare	Unmanned Systems	MILSATCOM Systems	Nuclear Submarines
Missile Defense BMC3	Federal, State / Local & Commercial		Navigation & Guidance	Airborne Ground Surveillance / C2	Environmental & Space Science Satellite Systems	Surface Combatants
Information Warfare	ISR, Homeland Security & Health		Military Space	Naval BMC2	Software Defined Radios	Expeditionary Warfare Ships
			Homeland Defense	Global / Theater Strike Systems	Directed Energy Systems	Auxiliary Ships
			Government Systems	Electronic Combat Operations	Strategic Space Systems	Fleet Maintenance
						Marine Composite Technology
						Coast Guard Cutters
						Commercial Ships

Information & Services | *Electronics* | *Aerospace* | *Shipbuilding*

A Portfolio Positioned for the Future

NORTHROP GRUMMAN

* *Includes Intersegment Eliminations*

† *Realigned Results*

Capability Developments for the Future are Built Upon a Legacy of Unmanned Aerial Systems

Unmanned. Unmatched.

NORTHROP GRUMMAN

DEFINING THE FUTURE™

1D01-AS-5026

Unmanned Systems
Integrated Capabilities and Support

- Global Hawk CONUS Flight Ops

- Global Hawk Flight Test

- UMS Support Center

NAS Pax River

- VTUAV Flight Test
- GHMD Flight Test

- Targets Operations

- Global Hawk Engineering
- X-47B UCAS Engineering
- Fire Scout Engineering
- Targets Development
- Rapid Prototyping

- X-47B UCAS Engineering

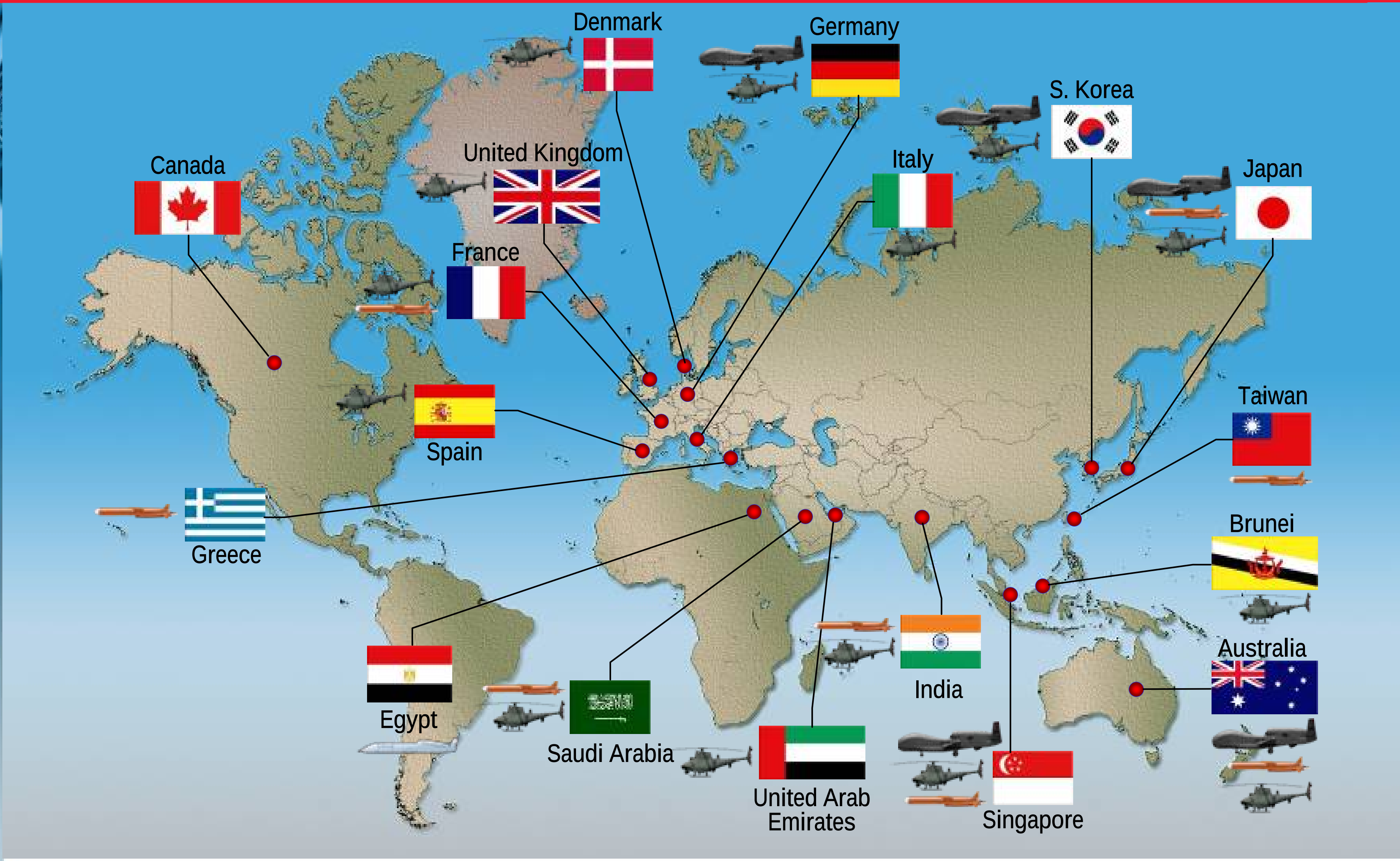
- Global Hawk Production
- Targets Production
- X-47B UCAS Production

- Fire Scout Production
- Global Hawk Production

NORTHROP GRUMMAN

Approved for Public Release
Control No. UMS-2007-906, May 2007

Unmanned Systems are Required Globally



NORTHROP GRUMMAN

Approved for Public Release
Control No. UMS-2007-906, May 2007

Key Capability Developments for the Future
Creating an Autonomous Environment

Product Development Investments

NORTHROP GRUMMAN

Approved for Public Release
Control No. UMS-2007-906, May 2007

End to End System Integration…

Global Hawk
System Center

X-47B UCAS
System Center

Fire Scout
System Center

VMS Lab

…Key to Success to Date

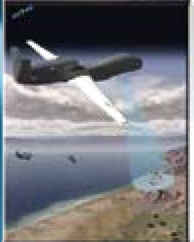
Approved for Public Release
Control No. UMS-2007-906, May 2007

Unmanned Systems Current Contracts

Global Hawk

Customer: ***US Air Force***

A combat proven high altitude, long endurance UAS with extraordinary ISR capabilities. Can provide near real time high resolution imagery of large geographical areas all day/all night in all types of weather.



GHMD

Customer: ***US Navy***

Maritime version of the high altitude, long endurance Global Hawk UAS with application for broad area maritime surveillance mission.

Euro Hawk

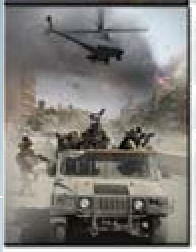
Customer: ***German MoD***

First International version of high altitude, long endurance Global Hawk UAS with German ELINT/COMINT sensor on board.

VTUAV Fire Scout

Customer: ***US Navy***

Navy multi-mission system. Operates autonomously from any aviation-capable warship, or unprepared landing zones in battle area.



FCS Class IV UAV

Customer: ***US Army***

Army Future Combat Systems multi-mission Class IV UAV for the Brigade Combat Team can provide RSTA, countermine, chemical detection, TUGS deployment, and logistics re-supply.

UCAS-D

Customer: ***US Navy***

Navy UCAS Carrier Demonstration will show that an operational class, tailless, LO-representative air vehicle can operate from a carrier at sea.

Hunter

Customer: ***US Army***

Army Reconnaissance, Surveillance and Target Acquisition (RSTA) system currently in service. Combat proven in multiple theaters and deployed in Iraq.

Targets

Customer: ***Multiple***

Low cost UAS for simulation of threat aircraft and missiles for combat training and weapons evaluations.

Model 324

Customer: ***Egyptian Air Force***

Autonomous, long range reconnaissance UAS providing EO and IR imagery.

1D01-AS-4781_Contracts

NORTHROP GRUMMAN

Approved for Public Release
Control No. UMS-2007-906, May 2007

Dynamic Program Updates

Global Hawk

Combat proven high altitude, long endurance UAS with extraordinary Intelligence, Surveillance, Reconnaissance (ISR) capabilities.

Provides near real time high resolution imagery of large geographical areas all day / all night in all types of weather.

NORTHROP GRUMMAN

Global Hawk Maritime Demonstration

Maritime version of the high altitude, long endurance Global Hawk UAS with application to the broad area maritime surveillance Concept of Operations (CONOPS) development.

NORTHROP GRUMMAN

Euro Hawk

Contracted in January 2007 with the German Ministry of Defence, Euro Hawk represents the first international development program for Global Hawk.

Ship-Based Fire Scout VTUAV System

X-47B UCAS

X-47B is the Navy Unmanned Combat Aerial System Carrier Demonstration (UCAS-D) program – demonstrating the ability of an unmanned, low observable platform to conduct operations from a carrier at sea to include: launch, recovery, deck handling and full integration into Carrier Air Traffic Control Center.

NORTHROP GRUMMAN

Approved for Public Release
Control No. UMS-2007-906, May 2007

X-47B UCAS-D Progress

X-47B UCAS-D Progress

New Unmanned Systems Pursuits

Navy UCAS

Customer: ***US Navy***

Completion of the UCAS-D program in 2013 is the first step toward an operational Navy UCAS strike / ISR platform.

Fire Scout International

Customer: ***Multiple***

Multi-mission system which has been source of many international requests to USN. High degree of interest in Europe and Asia.

AGS

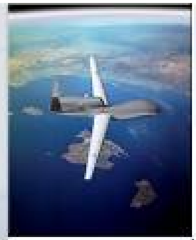
Customer: ***NATO***

NATO System consisting of a combination of manned and unmanned systems to provide ISR capabilities. Unmanned component is a Global Hawk UAS.

USCG FS

Customer: ***USCG***

Potential Fire Scout application for U.S. Coast Guard. Autonomous system that can land on any air capable ship.



BAMS

Customer: ***US Navy***

Maritime, high altitude, long endurance Intelligence Surveillance Reconnaissance and Targeting (ISR&T) system based on combat-proven Global Hawk.

VUAS

Customer: ***USMC***

Potential Fire Scout application for Marines. Autonomous system that can land in battlefield areas and act as communications relay.

Targets International

Customer: ***Multiple***

Low cost UAS for simulation of threat aircraft/missiles for combat training and weapons evaluations. Currently sold to various nations.

ACIS Projects

Customer: ***Multiple***

The Advanced Capabilities and Integrated Solutions Projects Team leads the way for the developmental and implementation of new technologies that will enhance the capabilities of unmanned systems.

1D01-AS-5281_Pursuits

NORTHROP GRUMMAN

Continuing to Support the Warfighter...

1D01-AS-4987


Unmanned. Unmatched.
NORTHROP GRUMMAN DEFINING THE FUTURE

ASTM International Committee F38 on Unmanned Aircraft Systems

Standardizing UAS Operations

NDIA Test & Evaluation Conference

25 February 2008

Presentation Overview

- ASTM F38 Mission & Vision
- How we can help you
  - Published & Draft Standards
- Background on ASTM International
- Some Specifics about F38
- Questions

Committee F38

- ***Vision***: **Provide routine, safe UAS operations in civil airspace through standardization.**

- ***Mission***: **Produce practical, consensus standards that facilitate UAS operations at an acceptable level of safety for use by industry, academia, government organizations and regulatory authorities.**

- ***Guiding Principle***: **Practical standards are a cost effective means of promoting commercial success, and that consensus processes protect the balance of interests among stakeholders.**

A Spectrum of Standards

Unregulated

Voluntary Industry Standards

Mandatory Industry Standards

Heavily Regulated

Kites
Balloons
Models

Ultralight Vehicles
Gliders

Light Sport *Aircraft*

Large Aircraft
Airlines
Pilots

F38 Subcommittee Structure

What do you need to fly?
…A System Safety Case

Airframe certification

Operations protocols & component performance

Crew training & human factors consideration

- **F38.01 Airworthiness Standards**
  - Safe design, construction, test, modification, & inspection of the individual component, aircraft, or system; ***hardware oriented***
- **F38.02 Operations Standards**
  - Safe employment of the system within the aviation environment among other aircraft & systems; ***procedure/ performance oriented***
- **F38.03 Pilot & Maintenance Qualifications**
  - Safe practices by the individuals responsible for employing the system; ***crew oriented***

F38.01: Subcommittee on Airworthiness

- What do you need to fly?
  - System certification
  - Operations protocols and component performance
  - Crew training and human factors consideration
- You would need
  - Reliability and Airworthiness Standards
    - Aircraft, Control Station, Datalink
  - Support Equipment Standards
    - Launch & recovery equipment
    - Starters, power supplies, fueling / de-fueling, others

F38.02 Subcommittee on Flight Operations

- What do you need to fly?
  - Airframe certification
  - Operations protocols and component performance
  - Crew training and human factors consideration
- You would need
  - Standardized flight procedures
  - Standardized maintenance procedures
  - Safe separation from other airspace users
  - Others, of course

F38.03 Subcommittee on Personnel

- **What do you need to fly?**
  - Airframe certification
  - Operations protocols and component performance
  - Crew training and human factors consideration
- **You would need**
  - Pilot certification system
    - Category and type, ratings, limitations
  - Criteria to certify aircrewmen
    - Eligibility, Knowledge, Experience, Test Standards
  - Criteria to certify maintainers
  - Others, of course

How We Can Help You: Published Standards

F2395-07	Standard Terminology for Unmanned Aircraft Systems
F2501-06	Standard Practices for UAS Airworthiness
F2585-06	Design & Performance of Pneumatic-Hydraulic Launch System
F2500-07	Standard Practice for UAS Visual Range Flight Operations
F2584-06	Standard Practice for Maintenance & Manuals for Light UAS
F2612-07	Standard Practice for Design and Manufacture of Turbine Engines for Unmanned Aircraft Systems
F2512-07	Standard Practice for Quality Assurance in the Manufacture of Light Airplane Unmanned Aircraft Systems
F2667-07	Standard Practice for Design and Manufacture of Reciprocating Compression Ignition Engines for Unmanned Aircraft Systems
F2635-07	Standard Classification for Unmanned Aircraft Pilot Certification
F2636-08	Commercial UAS Pilot Practical Test Standards

How We Can Help You: Items In Work

WK11425	Private UAS Pilot Practical Test Standards (Dave Gibbs)
WK13935	Standard Guide for Mini-UAS Airworthiness (Jason Stiffey)
WK13989	Standard Practice for Mini-UAS Visual Range Operations (Dave Grilley)
WK12989	Standard Practice for Mini-UAS Operators (Dave Grilley)
WK8962	Standard Practice for Remote Control Pilots Operating within Visual Range (Dave Grilley)
WK13686	Suggested Procedures Guide for Applying for UAS Special Issuance and Type Certificates (Dr. Gerry Marsters, former Transport Canada Regulator)
WK15881	Specification for Design and Performance of UAS Recovery Systems

Leveraging Community Expertise

Community Value

- **Applying These Standards**
  - Package: Mini-UAS in Visual Range
    - Airworthiness (WK13935)
    - Operations (WK13989)
    - Pilots (WK12989)
  - Creates a Safety Case
    - For Regulators
    - For Insurers
- **Buyer / User Adoption**
  - Simplifies procurement process
  - Enables interoperability

ASTM's Standards Development

- A Proven and Practical System that is Driven by Direct-Stakeholder Participation, for Developing Voluntary, Consensus Standards for Materials, Products, Systems & Services World-Wide.
- A Portfolio of Approximately 12,000 Standards Used Internationally; 3,500 are the Basis of National Standards and Regulation in 76 Countries.
- Always Reflect Current Technology as they are Continually Revised.
- Over 31,000 Members from 130 Countries Participate on ASTM International Committees; users from 175 countries.
- Standards Development Process complies with WTO's TBT Requirements.
- No Project Costs.

140 Technical Committees

A FEW OTHER EXAMPLES………

- A01 on Steel, Stainless Steel, & Related Alloys
- B07 on Light Metals & Alloys
- D02 on Petroleum Products & Lubricants
- D20 on Plastics
- E34 on Occupational Health & Safety
- E54 on Homeland Security Applications
    - E54.08 on Operational Equipment / Urban Search & Rescue Robots
- F04 on Medical Devices
- F37 on Light Sport Aircraft
- F39 on General & Utility Category Aircraft Wiring Systems
- F41 on Unmanned Undersea Vehicle Systems

What is a “Consensus Standards Body”

- Attributes
  - Openness with a “balance” of interest
  - Formal processes including appeals
  - Consensus (vice unanimity)
    - Must include a method for resolving negatives
- What is not
  - Company standards
  - Government standards
  - Standards mandated by law
  - Market driven “de facto” standards
    - Examples: VHS, MS Windows

Defining F38's "Balance"

- Member Type
  - Individual: $75 annual dues
  - Corporation: $400 annual dues
  - Temporary: Courtesy trial membership
- Classification
  - Producer: Seller of products and services
  - User: Buyer of products and services
  - General: Other interested parties
- Voting Status
  - Tracked by:
    - Type
    - Classification
    - Interest (i.e., company or organization)

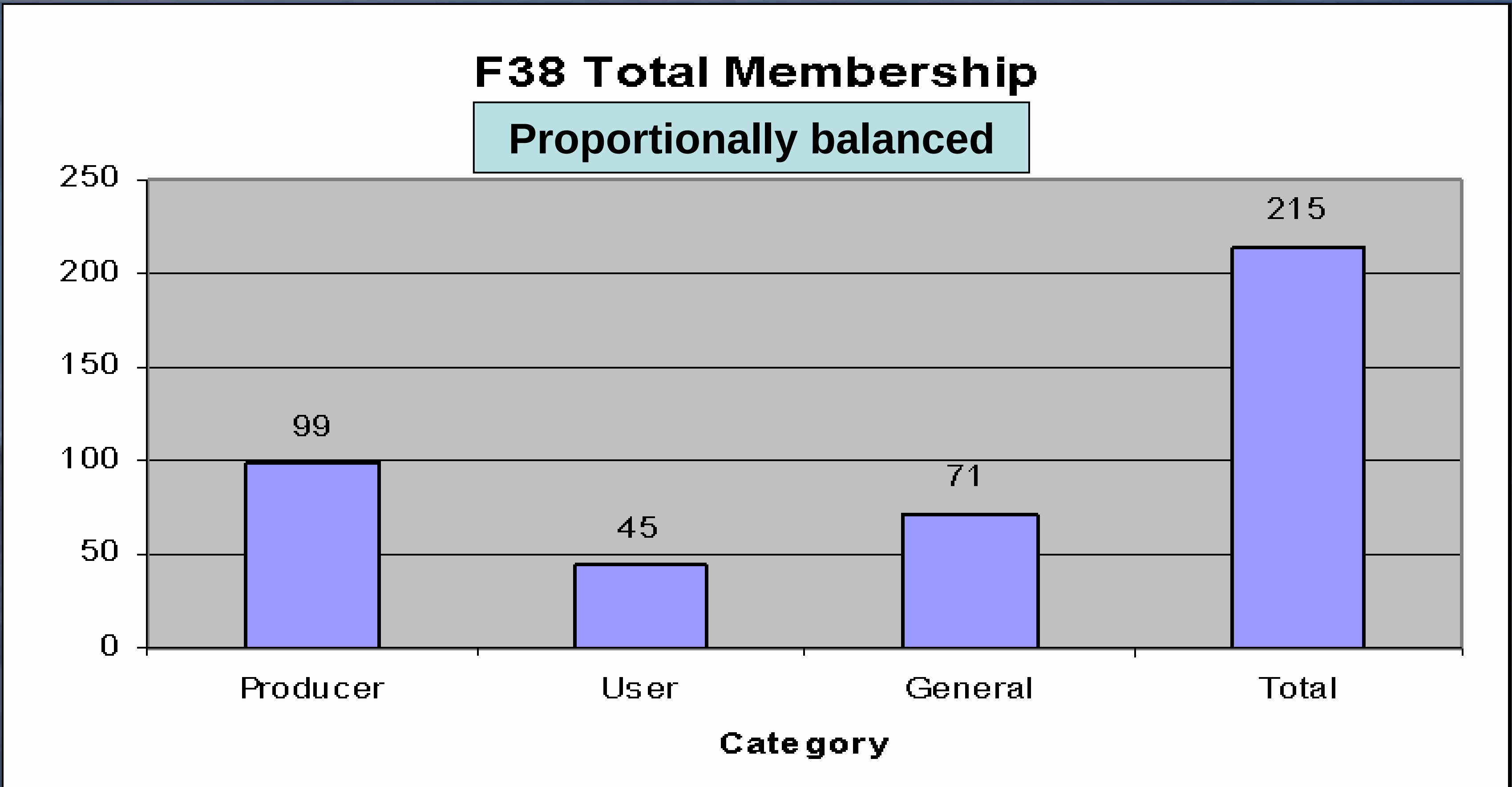
F38 Membership Report – Dec 07

- **215 Members**
  - 18 Countries / 4 Continents

Australia	1
Bahamas	1
Canada	5
Chile	1
Finland	1
France	1
Germany	6
Israel	2
Japan	6

Republic of Korea	1
New Zealand	1
Singapore	4
Slovenia	1
Spain	1
Sweden	4
Taiwan	3
United Kingdom	2
United States	177

F38 Membership Report – Dec 07



ASTM International Committee F38 on Unmanned Aircraft Systems

QUESTIONS?

Daniel A. Schultz
ASTM International
Manager, Standards Development

1+ 610-832-9716

dschultz@astm.org

www.astm.org

100 Barr Harbor Drive

W. Conshohocken, PA 19428-2959

USA

Jim Jewell
UAV Marketspace
F38 Membership Secretary

+1 (516) 558-7981

james@uavm.com

PO Box 330

Oyster Bay, NY 11771

USA

Industrial Committee on Operational Test and Evaluation (ICOTE)

Larry Graviss, Eagle Engineering
Committee Chairman

Dr. Charles McQueary, DOT&E,
Co-Chairman

27 February 2008

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

ICOTE Organizing Principles

The objectives of the ICOTE are to:

- Provide a forum for discussion and exchange of T&E views from Defense and the Industrial Base in a non-attribution environment
- Gain feedback from senior industry representatives and OSD leadership
- Discuss OSD and service policies which affect relationships with industrial suppliers
- Discuss emerging issues / policies in government and industry which affect the readiness and capabilities of U.S. defense system producers
- Cooperate on various projects of mutual benefit to the ICOTE participants

ICOTE
Current Membership

CURRENT NDIA T&E
ICOTE PARTICIPANTS

NDIA PARTICIPANTS

Lt Gen Larry Farrell, USAF (Ret) Pres & CEO, NDIA
Sam Campagna; Director of Operations
James O'Bryon: Chair T&E Division

GOVERNMENT MEMBERS

Dr. Charles McQueary DOT&E
David Duma DOT&E
Dr. Ernie Seglie DOT&E
RDML Bill McCarthy, USN ret. DOT&E
Michele Williams NGA
Brian Simmons AEC
Mike Crisp DOT&E
Maj Gen Roger Nadeau ATEC/CG
Maj Gen Steve Sargeant AFOTEC CC
RDML Stephen Voetsch OPTEVFOR
B/G David Eichhorn Edwards /CG
Colonel Mike Bohn MCOTEA
Dr. Steve Hutchison DISA
Jim Streilein ATEC
Steve Whitehead OPTEVFOR
Juan Vitail PEO CBD

ICOTE
Current Membership

CURRENT NDIA T&E
ICOTE PARTICIPANTS

INDUSTRY MEMBERS

Oscar Arroyo Raytheon
Brian See ATK
Regis Luther BAE
Steve Zink Oshkosh
Jim Ruma General Dynamics Land Sys
Martin Peryea Bell Hellicopter
Parker Horner EWA
Bill Keegan SAIC
Steve Kimmel Alion
Bill Shane Boeing
Jim Vosper Boeing
Doug Pearson Lockheed Martin
Joe Sweeney Lockheed Martin
Jon Neasham Cubic
Yank Rutherford Northrop Grumman
Gene Fraser Northrop Grumman
Tom Quinn BAH
Larry Graviss Eagle Engineering
Jim O’Bryon, O’Bryon Group

ICOTE

- **MEETINGS**

  The ICOTE will meet at the call of the Chairman and Co Chairman at sites and times convenient to the members.

  Minutes of the ICOTE will be provided to all members in the form of Agendas and action items as determined by the Director of OT&E.

  Topics of interest for consideration by the ICOTE will be solicited from industry and government members.

ICOTE Themes for The past year

Themes for 2007 /2008

Temp Process Change – DISA

IA Test Policy, CND testing IO range

Mil Std 785 B and using industry std.

Special Subjects

Sustainment and Evolutiona ry AQ

MRAP RFP

FCS Sustainment Program

MDA Test Methodology

JIEDDO approach to T&E

Threat Based Methodologies @ MS

DISA

USAF Test Command

APG Frag Kit 6 / MRAP testing

M&S CVN 21

ICOTE Sub-Committee on Space

Reports

• DSB Report

EVALUATING THE AUTONOMY OF UAVs

Herbert Hecht, Ph. D.
SoHaR Incorporated
Culver City, California

NO HUMAN PILOT

- SAVES WEIGHT
- SIMPLIFIES DESIGN
- INCREASES LOSS ACCEPTANCE
- EXTENDS FLIGHT ENVELOPE

- ALL HANDLING OF ANOMALOUS CONDITIONS MUST BE PROGRAMMED AND TESTED IN ADVANCE

EXCEPTION HANDLING

SOFTWARE TESTING

REQUIREMENTS BASED

- ALL STATED REQUIRE-MENTS HAVE BEEN IMPLEMENTED
- EXECUTION PRODU-CES DESIRED RESULTS

STRUCTURAL

- TRAVERSAL OF IMPLEMENTED PATHS PRODU-CES NO UNDESIRABLE RESULTS

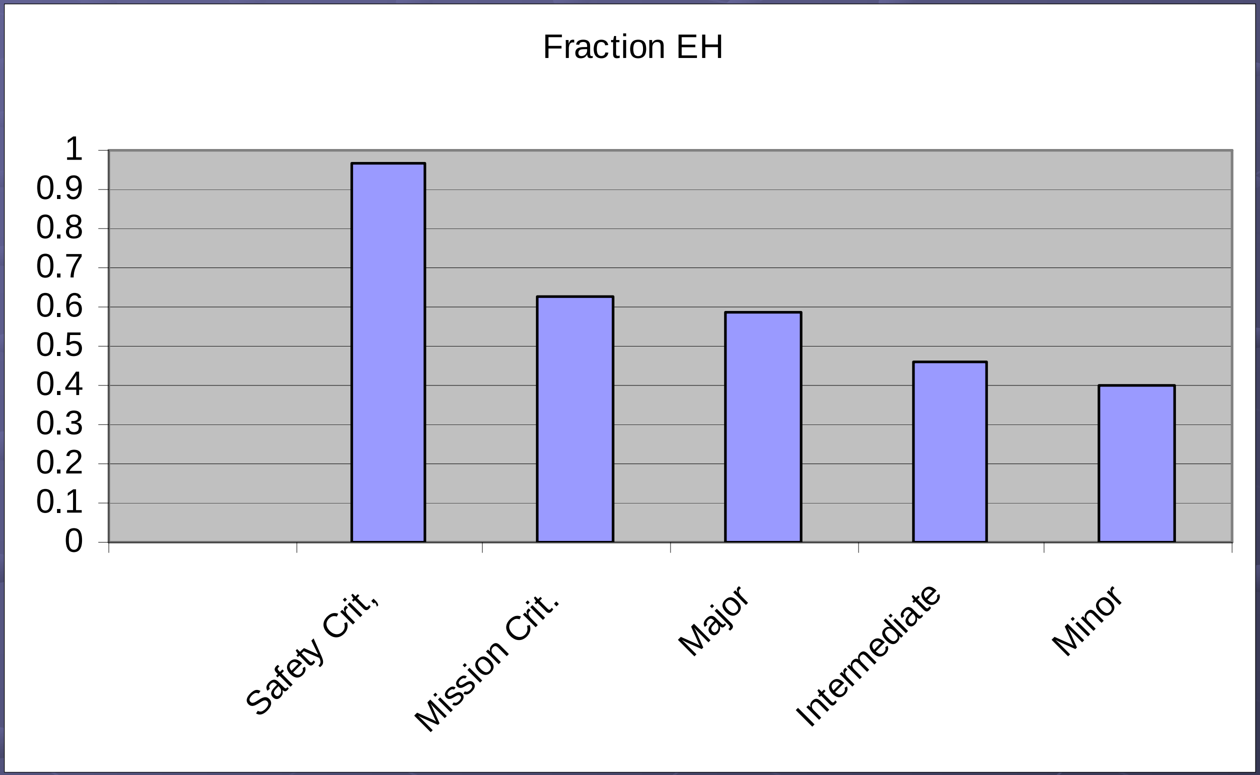
NEITHER APPROACH ASSURES ADEQUACY OF EXCEPTION HANDLING

EXCEPTION HANDLING

- VERY LITTLE LITERATURE
  - EXCEPT FOR LANGUAGE CONSTRUCTS
- NO GUIDANCE FOR SYSTEM LEVEL REQUIREMENTS FORMULATION
- MOST SOFTWARE FAILURES IN WELL-TESTED SYSTEM ARE DUE TO FAULTY EXCEPTION HANDLING

EXCEPTION HANDLING AND CRITICALITY

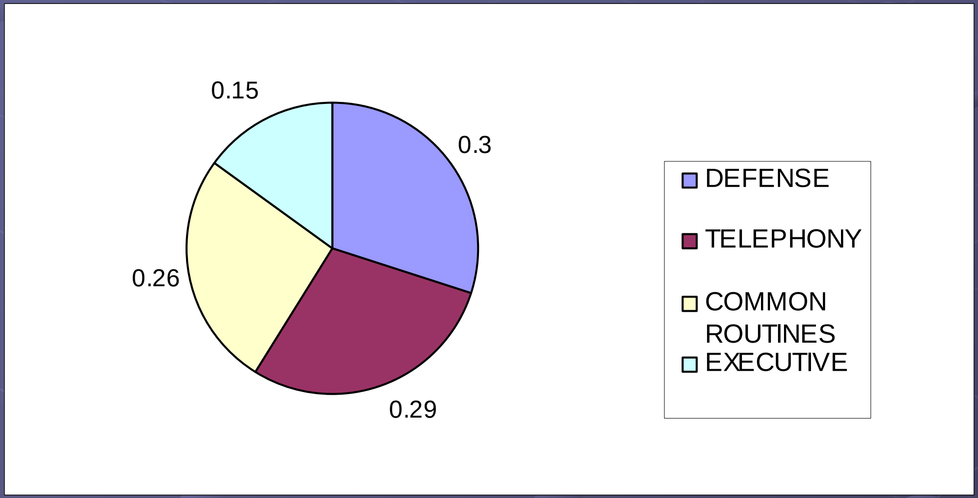
SPACE SHUTTLE AVIONICS SOFTWARE



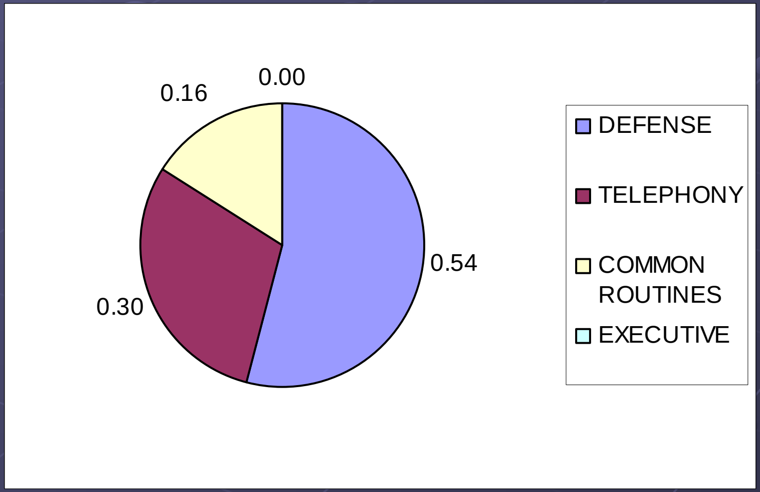
Hecht, H. and P. Crane, “Rare Conditions and their Effect on Software Failures”, *Proc. of the 1994 Annual Reliability and Maintainability Symposium”,* January 1994, pp. 334 – 337.

MORE EXCEPTION HANDLING FAILURES

ALL FAILURES



GLOBAL FAILURES



Kanoun, K. and T. Sabourin, “Software Dependability of a Telephone Switching System”, *Digest of Papers, FTCS-17,* Pittsburgh PA, July 1987, pp. 236 – 241

RELEVANT QUOTES

“The main line software code usually does its job. Breakdowns typically occur when the software exception code does not properly handle abnormal input or environmental conditions – or when an interface does not respond in the anticipated or desired manner.”

C. K. Hansen, *The Status of Reliability Engineering Technology 2001*, Newsletter of the IEEE Reliability Society, January 2001

“Therefore the identification and handling of the exceptional situations that might occur is often just as (un)reliable as human intuition.”

Flaviu Cristian “Exception Handling and Tolerance of Software Faults” in *Software Fault Tolerance,* Michael R. Lyu, ed., Wiley, New York, 1995

SPECIFYING EXCEPTION HANDLING IS DIFFICULT

- EXCEPTION CONDITIONS ARISE FROM SEVERAL LEVELS

SPECIFYING EXCEPTION HANDLING IS DIFFICULT

- EXCEPTION CONDITIONS ARISE FROM SEVERAL LEVELS
- EXCEPTION CONDITIONS ARE MORE DIFFICULT TO UNDERSTAND THAN MAIN LINE REQUIREMENTS

SPECIFYING EXCEPTION HANDLING IS DIFFICULT

- EXCEPTION CONDITIONS ARISE FROM SEVERAL LEVELS
- EXCEPTION CONDITIONS ARE MORE DIFFICULT TO UNDERSTAND THAN MAIN LINE REQUIREMENTS
- EXCEPTIONS OCCUR INFREQUENTLY BUT REQUIRE DISPROPORTIONATE EFFORT

SOURCES OF EXCEPTIONS

OPERATIONAL REQUIREMENTS

- LOSS OF PROPULSION, ELECTRIC POWER, COMMUNICATION, THERMAL CONTROL

IMPLEMENTATION DETAIL

- CALIBRATION ANOMALIES, ACTUATOR STATES, SENSOR INPUT

COMPUTING ENVIRONMENT

- HARDWARE FAILURES, MEMORY ERRORS, EXECUTIVE, MIDDLEWARE

MONITORING AND SELF-TEST

- OVER-TEMPERATURE SENSORS, SYSTEM PERFORMANCE TEST

APPLICATION SOFTWARE

- ASSERTIONS, VIOLATION OF TIMING CONSTRAINTS, MODE CHANGES

WHO IS RESPONSIBLE?

OPERATIONAL REQUIREMENTS

SYSTEM ENGINEERING

IMPLEMENTATION DETAILS

EQUIPMEMT SPECIALIST

COMPUTING ENVIRONMENT

MONITORING AND SELF-TEST

VEHICLE HEALTH MGM'T

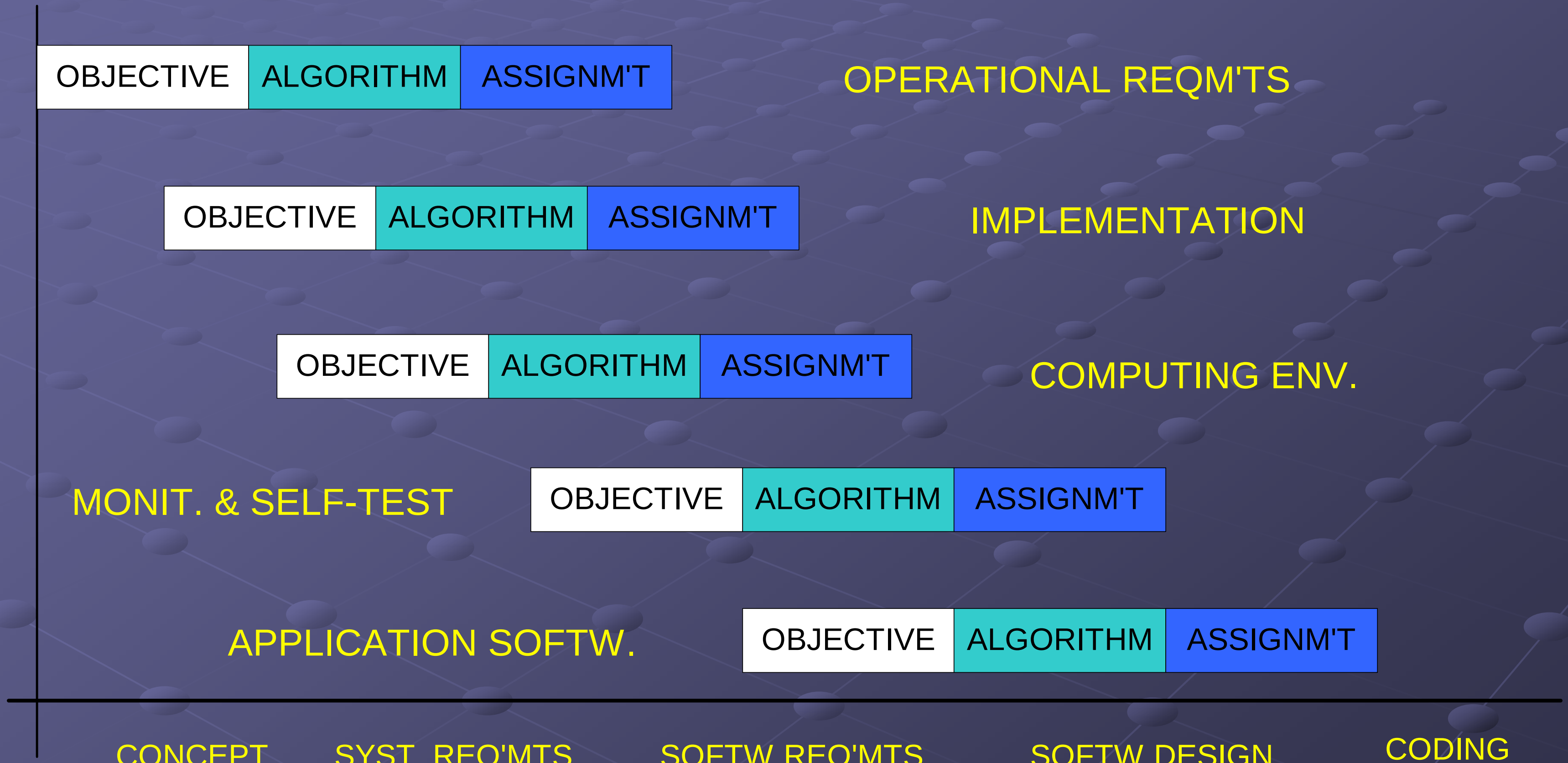
APPLICATION SOFTWARE

SOFTWARE ENGINEERING

REQUIREMENT GENERATION

- OBJECTIVE
  - EXCEPTION CONDITION AND ACTION
- ALGORITHM
  - QUANTITATIVE CONDITION DESCRIPTION
  - TIMING AND RESPONSIBILITY FOR ACTION
- ASSIGNMENT
  - SPECIFY SOFTWARE IMPLEMENTATION OF ALGORITHM

DOES IT ADD UP?



SOLUTIONS TO THE PROBLEM

- SHARING EXISTING PRACTICES
- SHARING EXPERIENCE
- CREATING AND SHARING TOOLS

- INTEREST GROUP
- STANDARDS WORKING GROUP
- RECOMMENDED PRACTICE

HERBERT HECHT

herb@sohar.com

310.338.0990 X110

New Mexico State University/ Physical Science Laboratory Technical Analysis and Applications Center

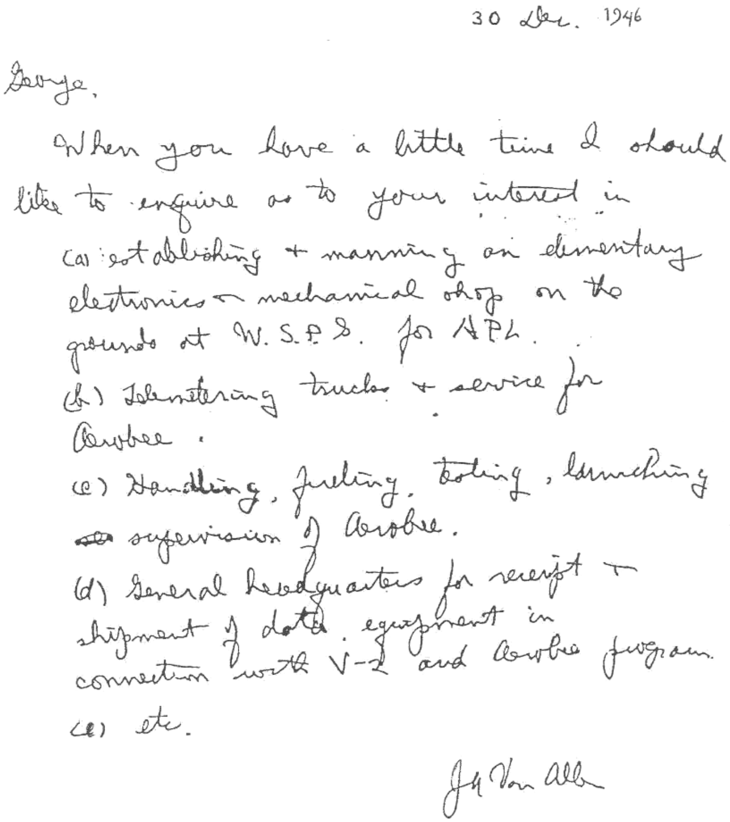
RDT&E to Advance UAS Access to the National Airspace System

Steve Hottman

February 28, 2008
24th Annual National Test & Evaluation Conference

NMSU/Physical Science Laboratory Overview

- Established in 1946 to support missile testing of V-2/Aerobee rocket testing at WSPG
- Multi-disciplined, aerospace- and defense-oriented scientific and technical organization
- A TOP SECRET cleared facility


30 Dec. 1946

George,

When you have a little time I should like to enquire as to your interest in
(a) establishing + manning an elementary electronics + mechanical shop on the grounds at W.S.P.G. for APL.
(b) Telemetering trucks + service for Aerobee.
(c) Handling, fueling, testing, launching supervision of Aerobee.
(d) General headquarters for receipt + shipment of data, equipment in connection with V-2 and Aerobee program.
(e) etc.

JA Van Allen

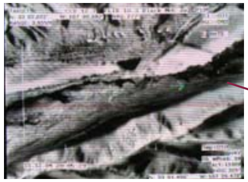
UAS Demonstrations and T&E

Las Cruces T&E WSMR

Denied GPS Environment

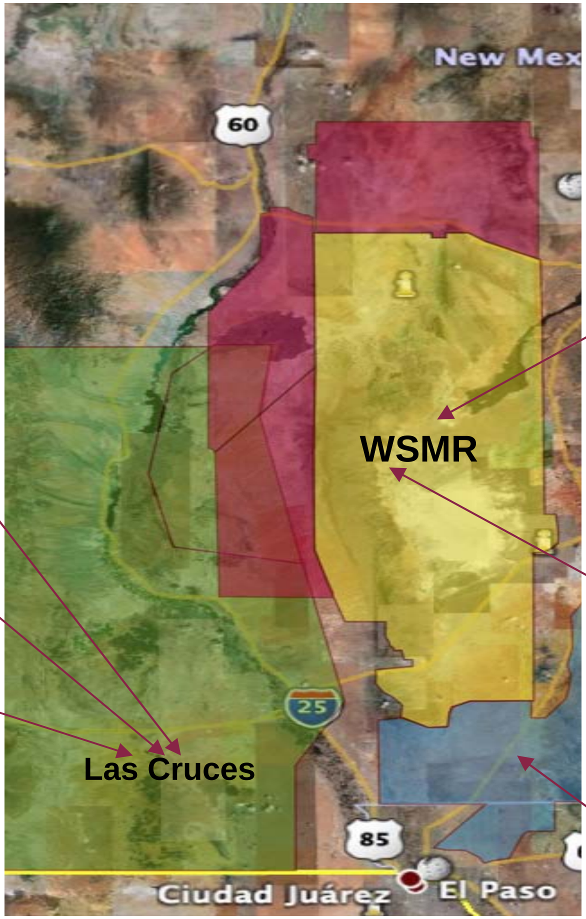
OSD-LEWK

DHS/Border



Combat Search & Rescue

Playas

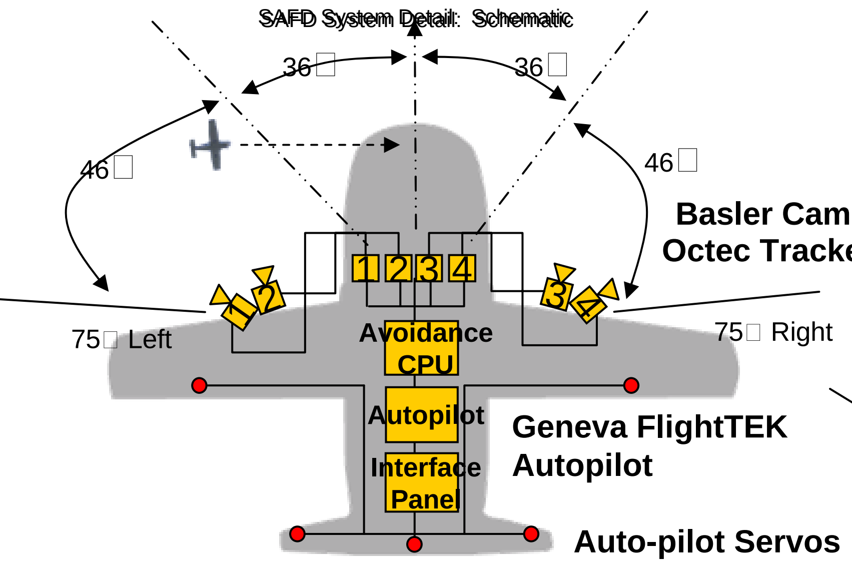


Asymmetric Threat

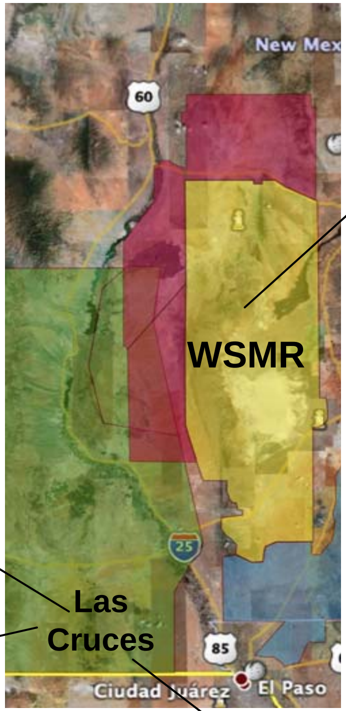
IED Demo

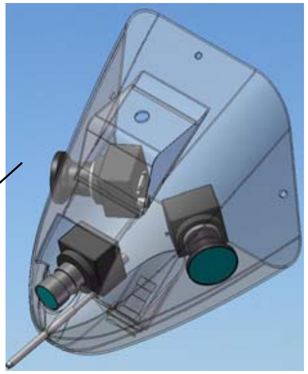
Orbiter

Detect, Sense, and Avoid



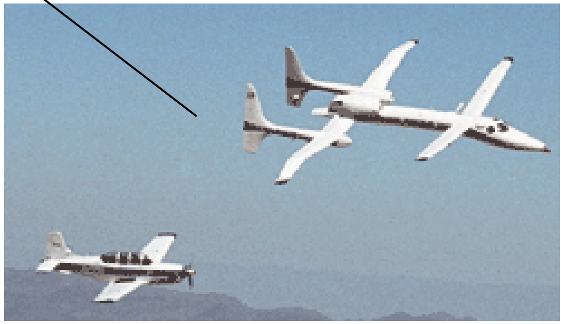
Sentinel and SAVDS





ATDSS-III

ERAST



Alaska

Fisheries

Fairbanks Area Fires

NORAD Traffic Separation

Trans Alaskan Pipeline Flight Route

Bering Sea Maritime Boundary Flight Route

Trans Alaskan Pipeline Flight Route

UAS Research

Air Traffic Control Research

Approach

Field evaluation of UAS symbology at FAA Air Traffic Control locations

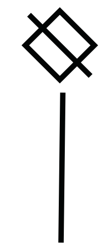
- Aircraft call sign

Participants

- Seattle, Albuquerque, Fort Worth, Denver, New York En Route Centers and New Orleans, Denver, High Desert (Edwards AFB), Tucson, Albuquerque TRACONs
- 53 ARTCC controllers, 46 TRACON controllers

Potential UAS Symbology

- Aircraft call signs are used by air traffic controllers to identify individual aircraft:
  - **UAV173**
  - **UM9417**
  - **UIN237** (uses aircraft registration number)
  - **UN4237** (uses aircraft registration number)
- The data block (right) appears on the controller's radar scope. Flight progress strips (below) are printed on pieces of paper.



UAV173
180C
426 223

UM9417 T/PRED/G T454 G499 89 **425** 04/1	SSO 360 017 0012	31 **00** EWM	**370**			SNA./.DR EWM J4 INK JEN5 DFW o UAV TYPE 2 PREDATOR	**6722**

UAS Operator Requirements

- Landing task description
  - 3 miles from airport
  - Lined up on centerline
  - 500’ AGL
  - Substantial crosswind
  - Runway – 200’ width; 7000’ long
  - Acceptable landing parameters
    - -- Runway location
    - -- Heading
    - -- Vertical velocity

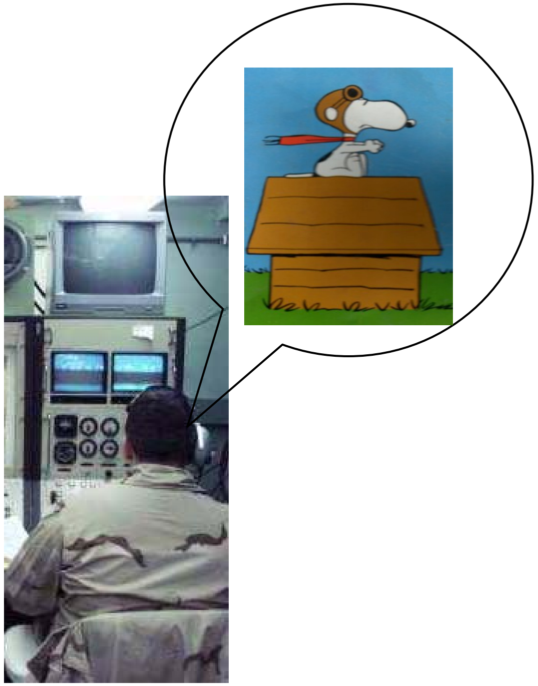
Results

- Data included as part of book chapter

  “Required Attributes and Skills of UAV Operators” for the future Human Factors of Remotely Piloted Vehicles volume of the Advances in Human Performance and Cognitive Engineering Research series.

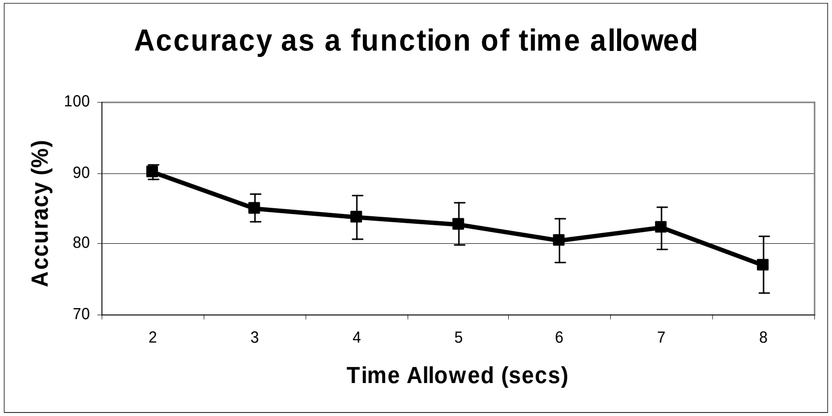
Handling Qualities

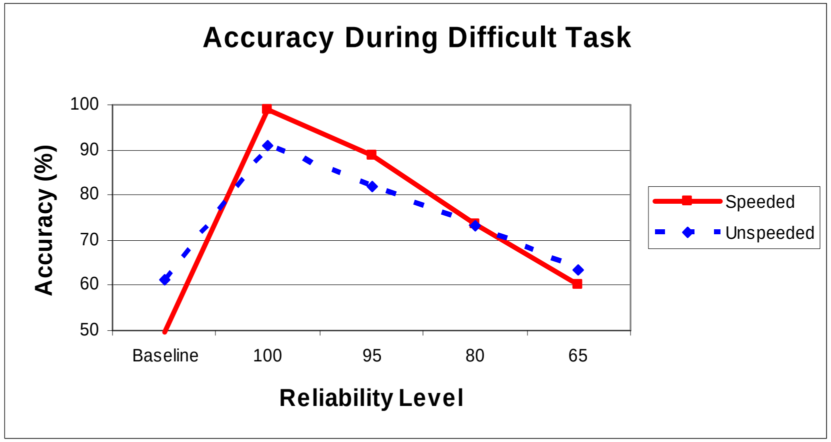
- Developing an assessment scale for UAS handling qualities. Derived from the Cooper-Harper aircraft handling qualities scale
- The UAS handling qualities scale will be multidimensional (unlike Cooper-Harper), non-intrusive, and will not compromise flight safety.
- The development of the UAS handling qualities scale will involve two empirical phases: dimension identification and validation. After scale construction, both content validity and inter-rater reliability will be empirically evaluated.



Trust in Automation

- Conducted an experiment that found time pressure increased trust and compliance in automation. This is beneficial to overall human-automation performance when the automation is highly reliable.
- Second experiment indicated that this increase in trust carries over to second session even when time pressure is removed.
- Third experiment indicated that time pressure is only effective when task is difficult and participants feel that the automation is doing a good job.
- Fourth experiment reveals a function by which the more time given to complete the task, the less compliance participants have in the automation.





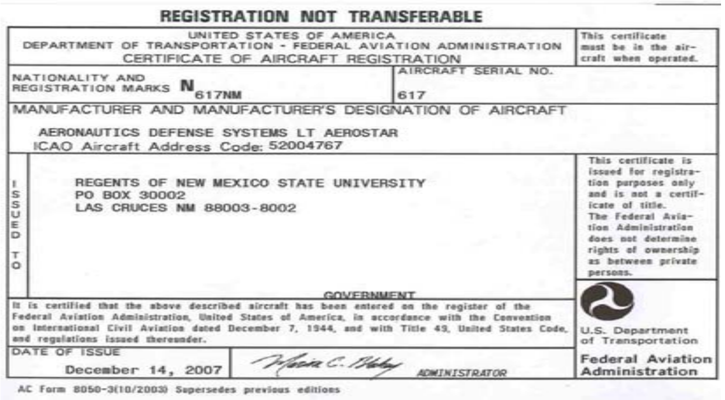
Physical Science Laboratory

TAAC

UAS Flight Test Center

UAS Regulatory Status

- No regulations exist for UAS; only guidance
- No empirical data exists to help drive regulatory development
- Access to airspace
- Civil – Experimental Airworthiness Certificate



REGISTRATION NOT TRANSFERABLE

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION - FEDERAL AVIATION ADMINISTRATION
CERTIFICATE OF AIRCRAFT REGISTRATION

This certificate must be in the air-craft when operated.

NATIONALITY AND REGISTRATION MARKS N617NM

AIRCRAFT SERIAL NO. 617

MANUFACTURER AND MANUFACTURER'S DESIGNATION OF AIRCRAFT
AERONAUTICS DEFENSE SYSTEMS LT AEROSTAR
ICAO Aircraft Address Code: 52004767

ISSUED TO
REGENTS OF NEW MEXICO STATE UNIVERSITY
PO BOX 30002
LAS CRUCES NM 88003-8002

GOVERNMENT

This certificate is issued for registration purposes only and is not a certificate of title. The Federal Aviation Administration does not determine rights of ownership as between private persons.

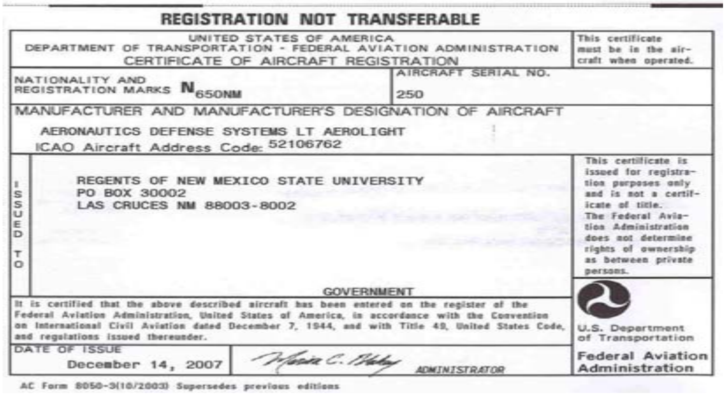
It is certified that the above described aircraft has been entered on the register of the Federal Aviation Administration, United States of America, in accordance with the Convention on International Civil Aviation dated December 7, 1944, and with Title 49, United States Code, and regulations issued thereunder.

DATE OF ISSUE December 14, 2007

ADMINISTRATOR

U.S. Department of Transportation
Federal Aviation Administration

AC Form 8050-3(10/2003) Supersedes previous editions



REGISTRATION NOT TRANSFERABLE

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION - FEDERAL AVIATION ADMINISTRATION
CERTIFICATE OF AIRCRAFT REGISTRATION

This certificate must be in the air-craft when operated.

NATIONALITY AND REGISTRATION MARKS N650NM

AIRCRAFT SERIAL NO. 250

MANUFACTURER AND MANUFACTURER'S DESIGNATION OF AIRCRAFT
AERONAUTICS DEFENSE SYSTEMS LT AEROLIGHT
ICAO Aircraft Address Code: 52106762

ISSUED TO
REGENTS OF NEW MEXICO STATE UNIVERSITY
PO BOX 30002
LAS CRUCES NM 88003-8002

GOVERNMENT

This certificate is issued for registration purposes only and is not a certificate of title. The Federal Aviation Administration does not determine rights of ownership as between private persons.

It is certified that the above described aircraft has been entered on the register of the Federal Aviation Administration, United States of America, in accordance with the Convention on International Civil Aviation dated December 7, 1944, and with Title 49, United States Code, and regulations issued thereunder.

DATE OF ISSUE December 14, 2007

ADMINISTRATOR

U.S. Department of Transportation
Federal Aviation Administration

AC Form 8050-3(10/2003) Supersedes previous editions

- Public – Certificate of Authorization

Need for UAS Flight Test Center

- COA process used for public aircraft operators
- Experimental airworthiness certificates required for commercial operators
  - Data must be generated to substantial airworthiness
    - To generate data, you must be able to fly
    - To fly in the NAS, you must have an experimental airworthiness certificate
    - To obtain an airworthiness certificate, flight data are required
- No authorized flight areas exist for UAS
- FAA needs data for development of regulations

Why A Test Center?

- UAS are Different
  - Manned Aircraft under testing and development can comply with 14 CFR Part 91
  - Private Industry needs a place to do basic Research and Development
    - Many are not ready for the FAA Experimental Certification process
    - Not just for aircraft…..payloads
  - UAS are still very immature

Why NMSU?

- Experience with UAS
  - Foundational SOP's in place and exercised
  - Ability to collect and process significant data
  - Solid and credible safety record
    - Over 8 years operational experience
  - Experienced UAS personnel
- Location –
  - "It's not the end of the world, but you can see it from there….."
  - Very sparsely populated
  - Low density Air Traffic
  - Climate is favorable

How?

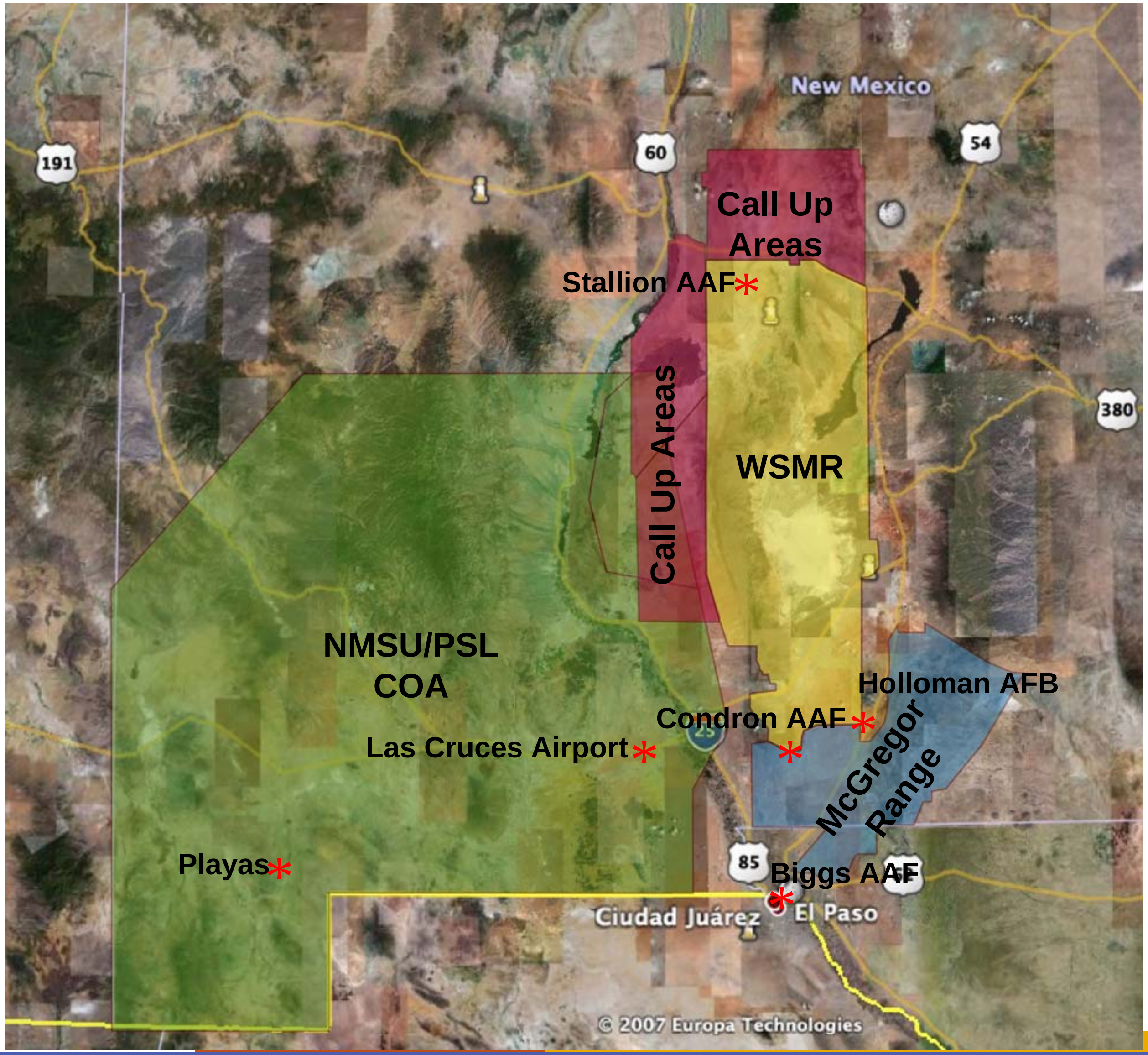
- Establishing a Cooperative Research and Development Agreement (CRDA)
  - Outlines the risk management process similar to that being applied by FAA today
- FAA will require data on a routine basis
- NMSU is a Public Organization and thus qualifies for a COA
  - All testing/R&D will be conducted as directed by FAA under the COA
- Provides for a controlled testing environment while minimizing impact to other NAS users as well as people/property on the ground

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Southwest New Mexico Airspace

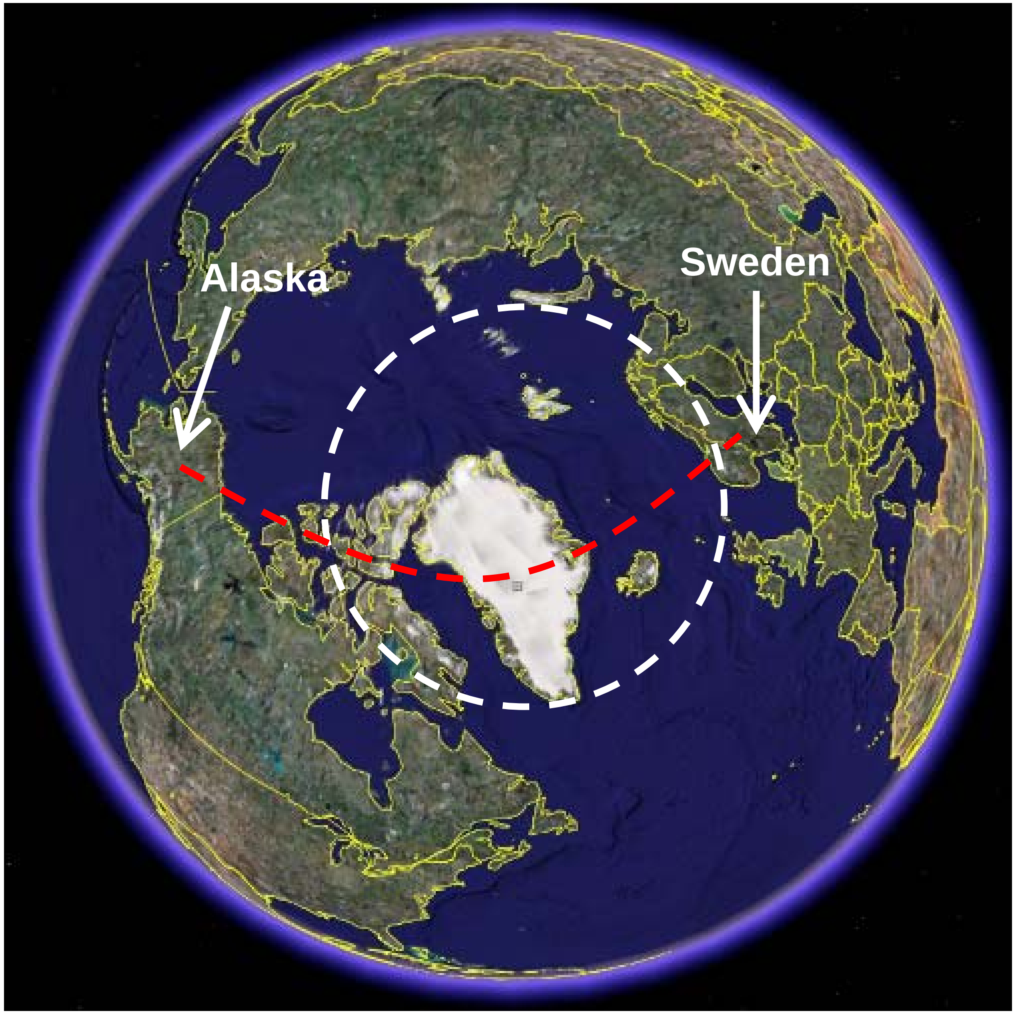
- Largest DoD-controlled air and ground space in the U.S.
- Slightly smaller than Connecticut – 7,105 sq mi
- USAF air traffic control from "surface to space"

- NMSU/PSL COA >12,000 sq mi



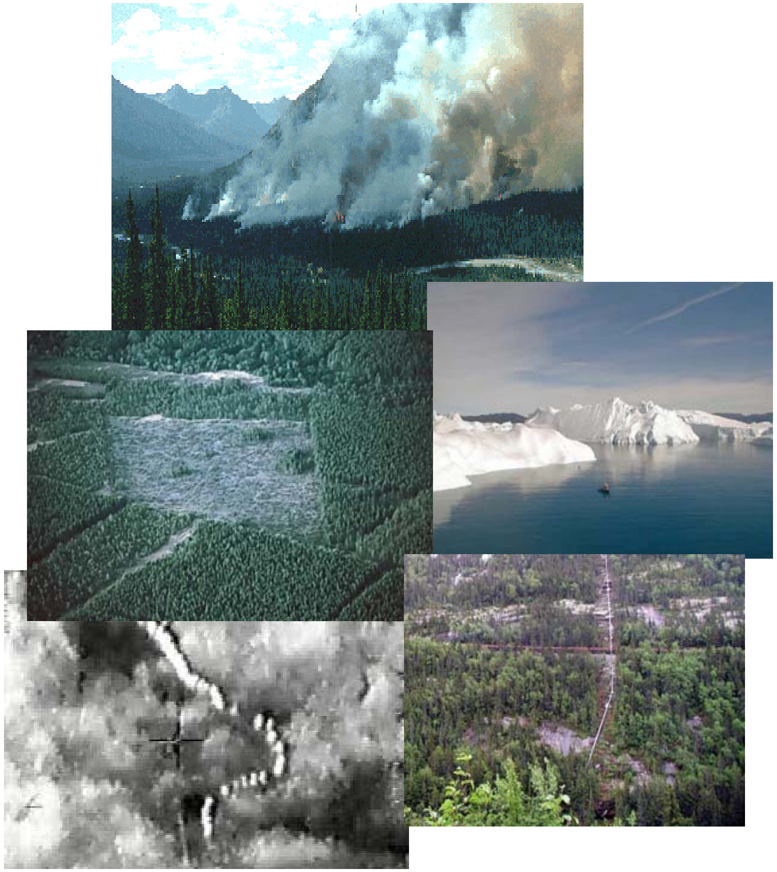
Sweden/Arctic

- Currently performing Arctic airspace study with FAA UAPO
- Arctic overflights proposed since 2003
- CY05 USA/Sweden Space Exploration Agreement and International Polar Year with Swedish Space Corporation
- High-altitude balloon experience



Summary

- Routine access to the NAS is not yet available
- The regulatory body for UAS requires development
- Significant RDT&E is required before realistic “file and fly” in the NAS exists
- Formal studies with resulting empirical data will assist with FAA certification issues



UAS Flight Test Center provides NAS access and a T&E environment

Joint Mission Environment Test Capability (JMETC)

Briefing for:

NDIA National Test and Evaluation Conference

February 27, 2008

Agenda

- Interoperability/NR KPP Test Requirement
- Program Overview
- FY07 Accomplishments
- FY08 Plan
- Concluding Remarks

Interoperability / Net-Ready KPP Testing Requirement

"It is expected any resultant materiel solution will be verified through testing conducted in the expected joint operational environment to demonstrate joint interoperability and, when appropriate, net-readiness"

CJCSI 3170.01F, dated 1 May 2007

- DoD Policy requires Joint interoperability and net-readiness testing during acquisition
- Interoperability and Net-Ready KPP testing requires testing interactions of multiple systems at the same time
  - Systems or their representations are not all co-located
  - Need to test early and throughout system development process
- Transition to the GIG to realize Net-Centric Warfare will increase the requirement for interoperability and, thus, increase the need for distributed testing

Interoperability, Net Ready Testing Challenges

- No “live” system available to test early in acquisition process
- Other systems needed to test interoperability/NR are in various stages of development
- Existing (legacy) systems needed for test are often unavailable due to real world commitments or too expensive to be made available
- Available “live” systems and system representations are scattered across the country on ranges, in integration laboratories, in simulations, and in other forms
- Difficult, time-consuming, and expensive to plan and execute distributed test events
  - Networks require time-consuming security agreements to be coordinated
  - Instrumentation data definitions differ from laboratory to laboratory
  - Lack of universal tools complicates test integration
  - Distributed test events require engineering each and every time

What is JMETC?

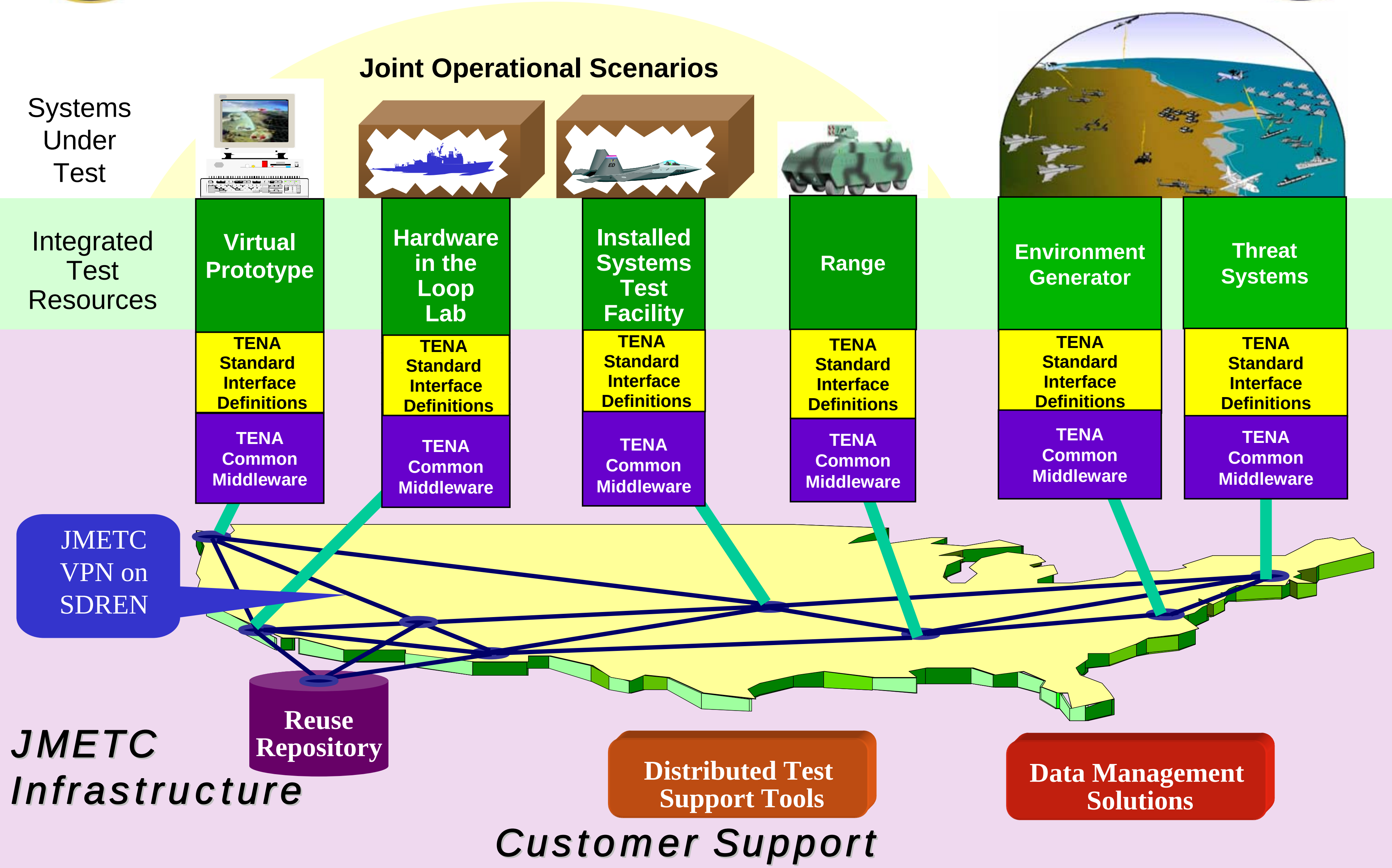
- A **corporate** approach for linking distributed facilities
  – Enables customers to efficiently evaluate their warfighting capabilities in a joint context
  – Provides compatibility between test and training
- A core, reusable, and easily reconfigurable infrastructure
  – Consists of the following products:
    - Persistent connectivity
    - Middleware
    - Standard interface definitions and software algorithms
    - Distributed test support tools
    - Data management solutions
    - Reuse repository
- Provides customer support team for JMETC products and distributed testing

JMETC Will Provide Infrastructure Capability for:

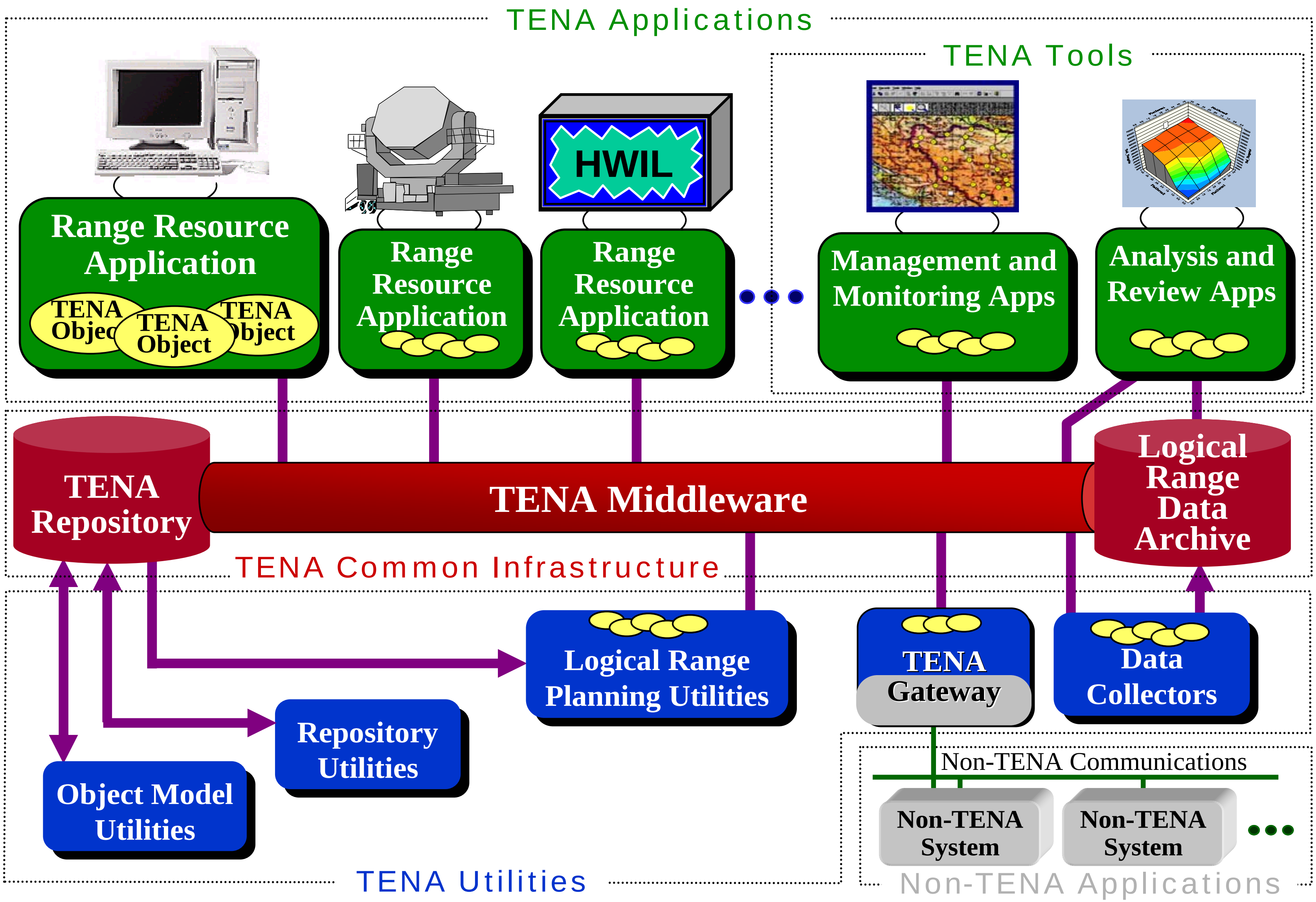
- Testing across full spectrum of acquisition process
  - Developmental Test, Operational Test
  - Interoperability Certification
  - Net-Ready KPP compliance
- Joint mission portfolio testing
- Evaluation of warfighting capabilities in joint mission environment
- Conduct of live, virtual or constructive testing
- Conduct of joint testing and training

Used whenever you need to link resources together to conduct a distributed test event

JMETC Enables Distributed Testing



TENA Architecture Overview



JMETC Leadership & Governance

JMETC Chain of Command

Honorable John Young
USD(AT&L)

Dr. John B. Foulkes
Director, Test Resource Management Center (TRMC)

Richard L. Lockhart
Principle Deputy, TRMC
Deputy Director, JIPP

Chip Ferguson
JMETC Program Manager

George Rumford
Systems Engineering Lead (Acting)

JMETC Governance

Testing in a Joint Environment Roadmap Senior Steering Group

- Senior DoD Leaders
- Charter signed 26 Oct 07

JMETC Advisory Group

- Service/Agency reps
- Regularly held meetings
  - Plans, needs, requirements
  - Priorities

JMETC Users Group

- Technical representatives of customers and test resource owners
- Three meetings held in Jun 07, Oct 07, and Jan 08
- 200 participants last meeting
- Next meeting May 08

JMETC Accomplishments – FY07
Summary

- Supported two major distributed test events
  - Integral Fire 07
  - InterTEC Spiral 2 Build 1
- Stood up the JMETC VPN on the SDREN
  - Established 8 locations on the JMETC VPN available for future use
    - Pax River, C2TF (@ Eglin), GWEF (@ Eglin), White Sands, Redstone, China Lake, Pt. Mugu, and JITC
- Initiated collaboration with the Training community
  - Used the JNTC-sponsored network aggregator in Integral Fire 07
  - Supported the JFCOM LVC Architecture Roadmap Study
- Established JMETC Advisory Group and JMETC Users Group
- Conducted a DoD Distributed Test Infrastructure Assessment
  - Approved by the Joint Capabilities Board (JCB)

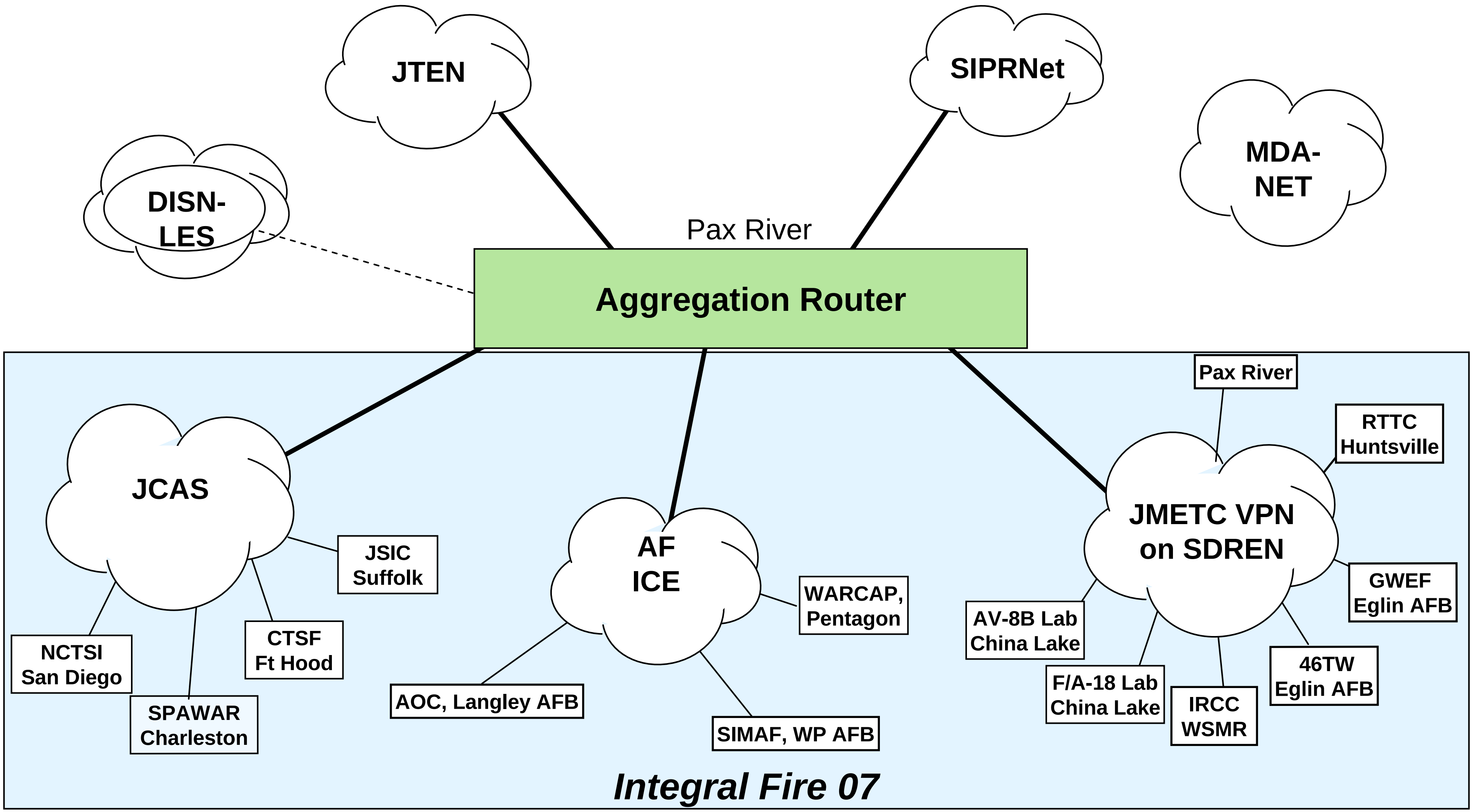
Integral Fire 07 Test Event

– Integral Fire 07 Description:
  - A combined, distributed test event conducted in August 07 supporting the following three customers:
    - JFCOM JSIC JCAS Assessment
    - JTEM Methodology Assessment
    - USAF Warplan-Warfighter Forwarder (WWF)

– JMETC Responsibilities:
  - Overall lead for creating the distributed test Infrastructure including JMETC VPN (5 locations)
  - Connect three enclaves (total of 15 locations) using the JFCOM aggregator router
  - Conduct systems integration, site surveys, and dry runs
  - Oversee operation of the network and data flow among all sites during the event

– JMETC Significant Accomplishments:
  - Stood up and successfully demonstrated the JMETC VPN within 90 days
  - Successfully used the Aggregation Router to link three enclaves
  - Supported three customers conducting tests using the same network in the same time frame

Network Aggregation Bridging Networks



InterTEC Spiral 2, Build 1 Test Event (FY07)

- Interoperability T&E Capability (InterTEC) Description:
  - OSD-sponsored, Navy-led project under the Central T&E Investment Program (CTEIP)
  - Purpose is to develop an accredited test capability to conduct joint interoperability certification and joint mission thread testing

- Spiral 2, Build 1 Objectives:
  - Developing and assessing tools to test joint threads
  - Assessing the C2 messages sent from sensors to shooters through command and control systems (GCCS-J, GCCS-M, GCCS-A, and TBMCS)

- JMETC Responsibilities:
  - Overall lead for creating the Infrastructure integrating 6 locations
  - Conduct systems integration, site surveys, and dry runs in preparation for the event
  - Oversee operation of the network and data flow among all sites during the event

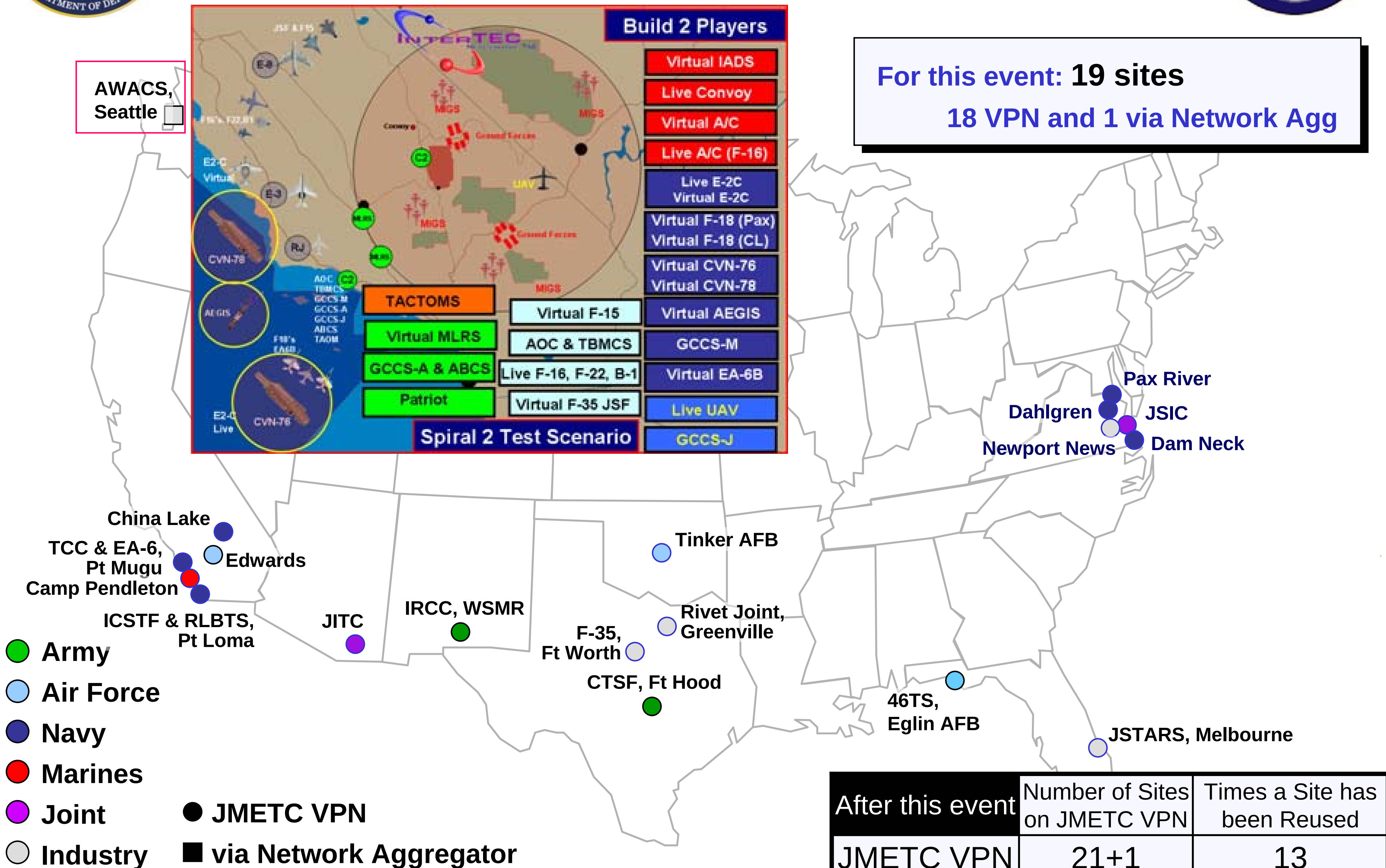
- JMETC Significant accomplishments
  - Established the new locations on the JMETC VPN within 90 days
  - Demonstrated re-use (three locations from Integral Fire 07 test)
  - Successfully used the Aggregation Router

FY 08 Plan

- Event Support
  - SIAP Risk Reduction (March 08)
    - Risk reduction test for a planned Oct 08 event
  - InterTEC Spiral 2, Build 2 (June 08)
    - Test OTH-G messages using a Joint Fires Scenario
    - Integrating 12 locations
    - Includes **CVN-21** participation
  - **FCS** Combined Test Organization / JTEM Test Event (July 08)
    - Test the JTEM Methods and Processes
    - Experiment and test of the infrastructure needed to evaluate joint functionality of FCS
  - InterTEC Systems Acceptance Test (August 08)
    - JITC acceptance test of InterTEC tools
- Collaboration with Training Community
  - Common distributed test and training infrastructure requirements
  - JFCOM-led LVC Architecture Roadmap Study
  - Demonstration of JTEN and JMETC VPN peering capabilities
- Support Other JMETC-related Activities
  - M&S Steering Committee
  - Distributed Test Infrastructure Studies
- Publish the JMETC Program Plan

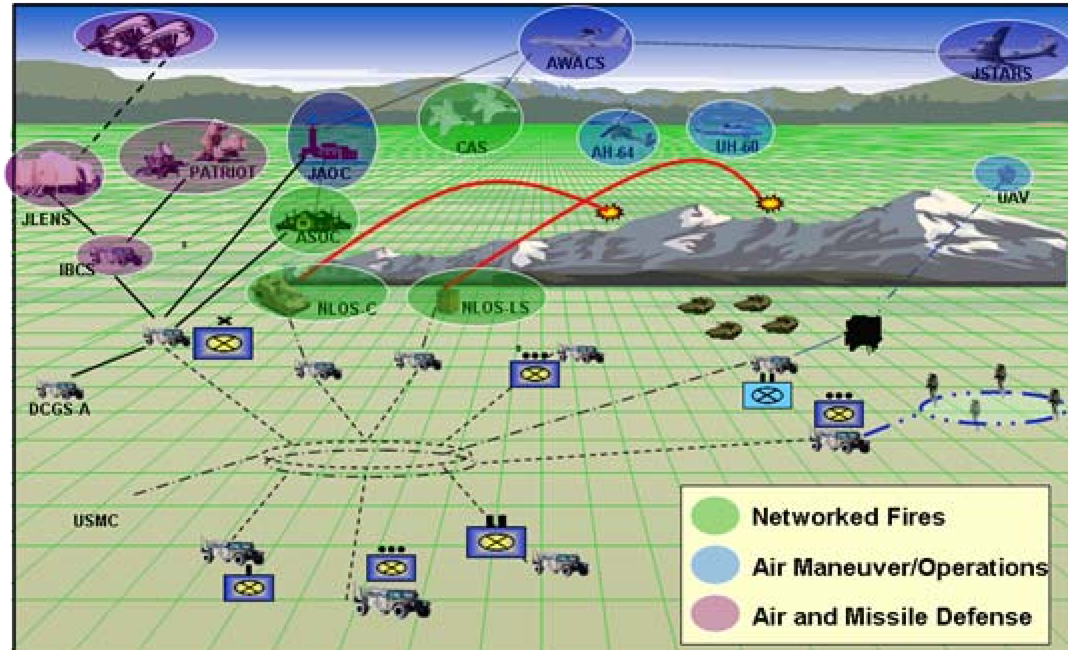
InterTEC Spiral 2 Build 2
JMETC VPN (Jun 16-27, 2008)

For this event: **19 sites**
18 VPN and 1 via Network Agg

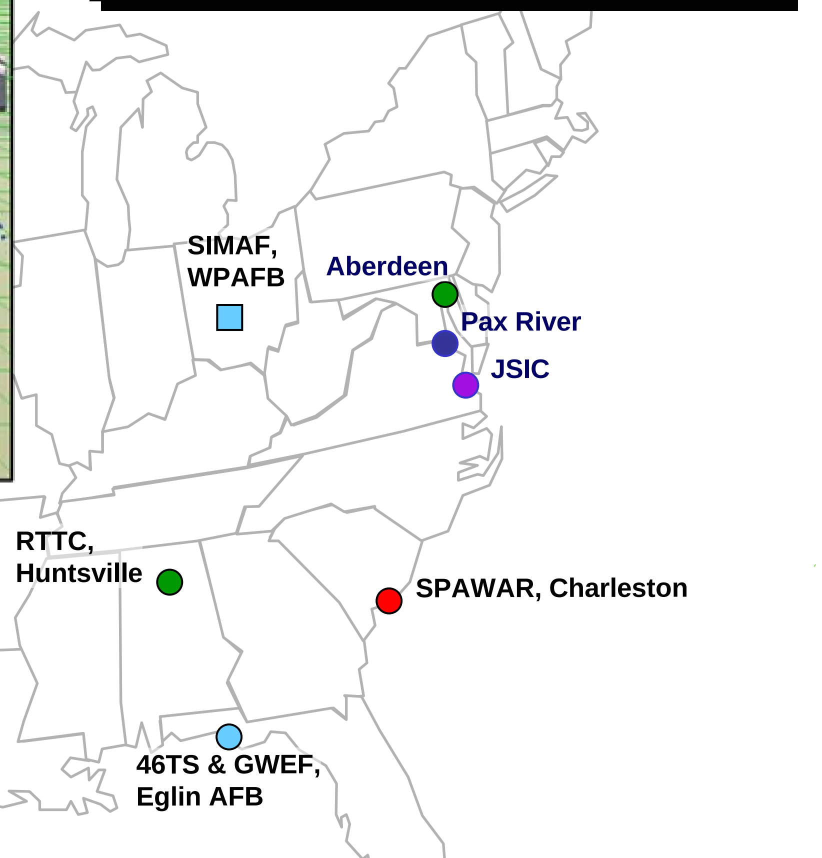


After this event	Number of Sites on JMETC VPN	Times a Site has been Reused
JMETC VPN	21+1	13

Joint Battlespace Dyn. Decon (FCS & JTEM)
JMETC VPN (Jul 28-Aug 1, 2008)



For this event: 9 sites
7 VPN and 2 via Network Agg

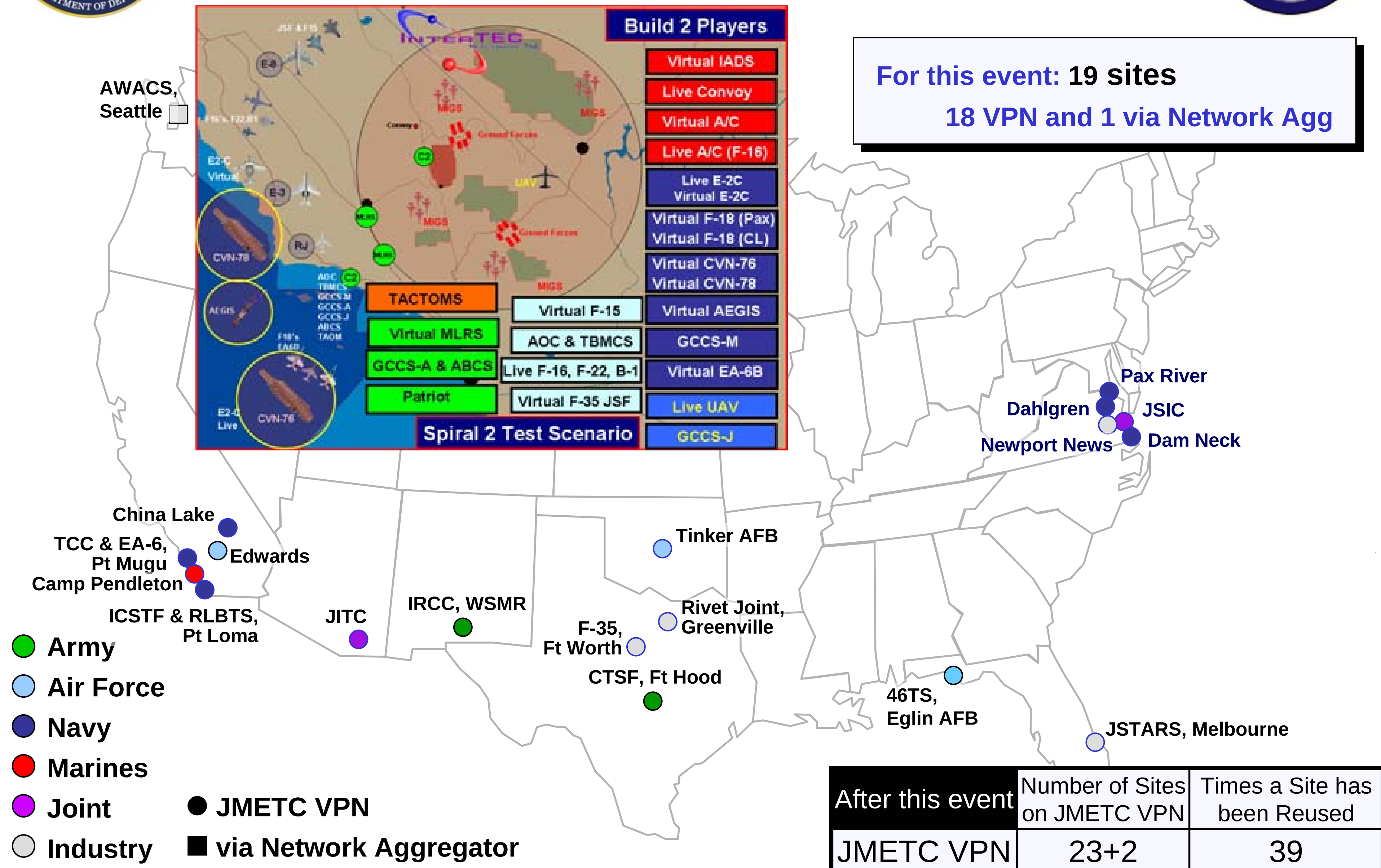


- Army
- Air Force
- Navy
- Marines
- Joint
- Industry
- ● JMETC VPN
- ■ via Network Aggregator

After this event	Number of Sites on JMETC VPN	Times a Site has been Reused
JMETC VPN	23+2	19

InterTEC System Acceptance Test
JMETC VPN (Aug 18-29, 2008)

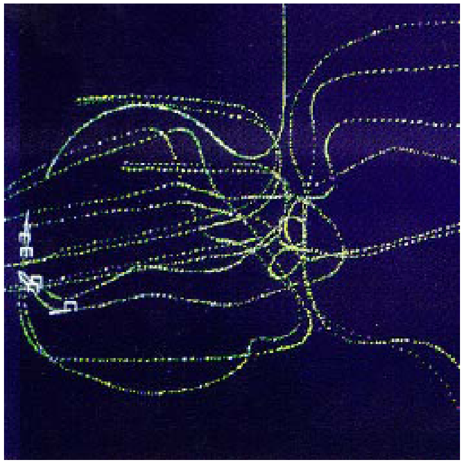
For this event: 19 sites
18 VPN and 1 via Network Agg



After this event	Number of Sites on JMETC VPN	Times a Site has been Reused
JMETC VPN	23+2	39

Single Integrated Air Picture (SIAP) – JCHE-5
JMETC VPN (1st Qtr FY2009)

SIAP Attributes:



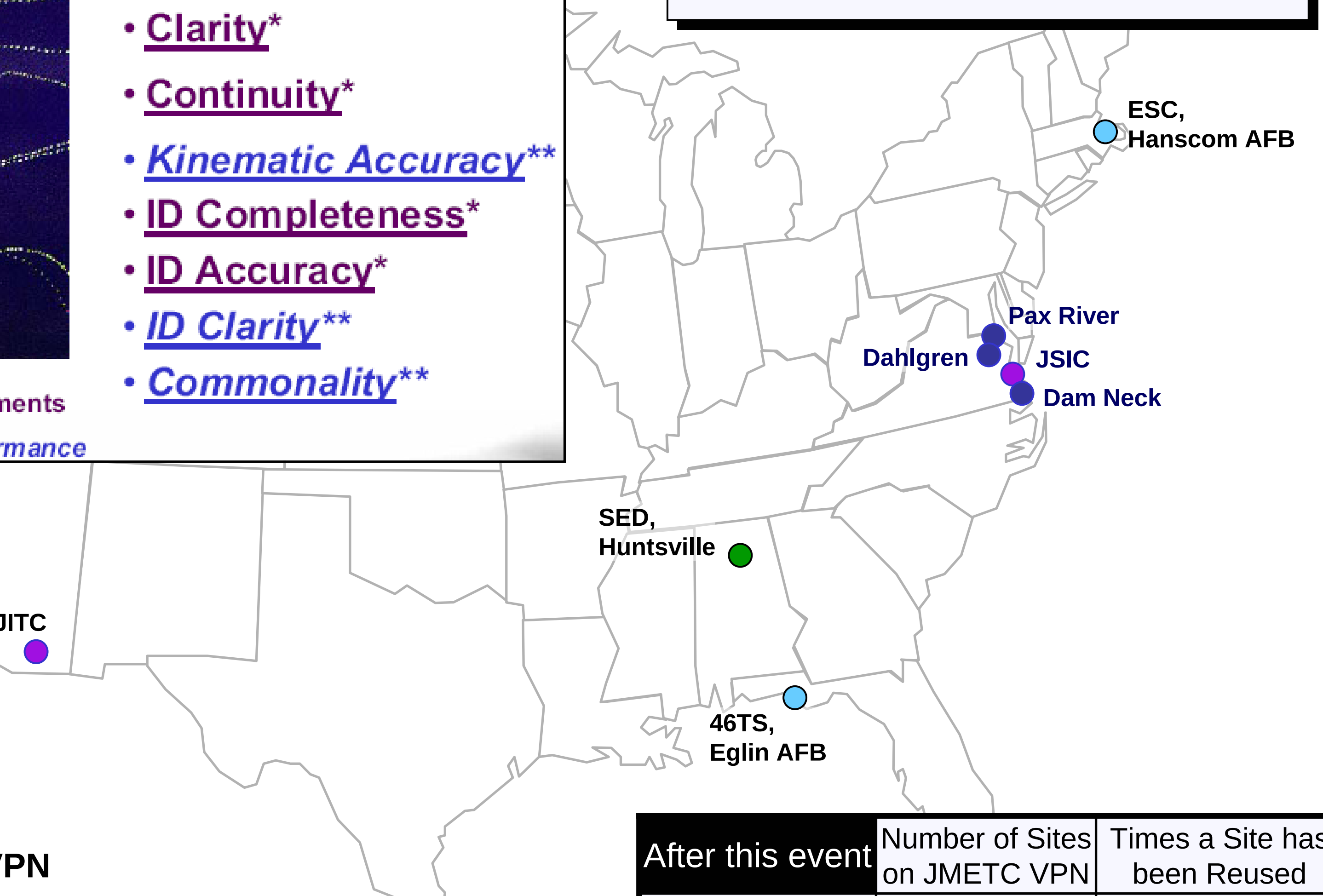
- Completeness*
- Clarity*
- Continuity*
- *Kinematic Accuracy***
- ID Completeness*
- ID Accuracy*
- *ID Clarity***
- *Commonality***

* JROC Approved Requirements

*** SIAP Measures Of Performance*

For this event: **8 sites**

All 8 sites on the JMETC VPN



- Army
- Air Force
- Navy
- Marines
- Joint
- Industry

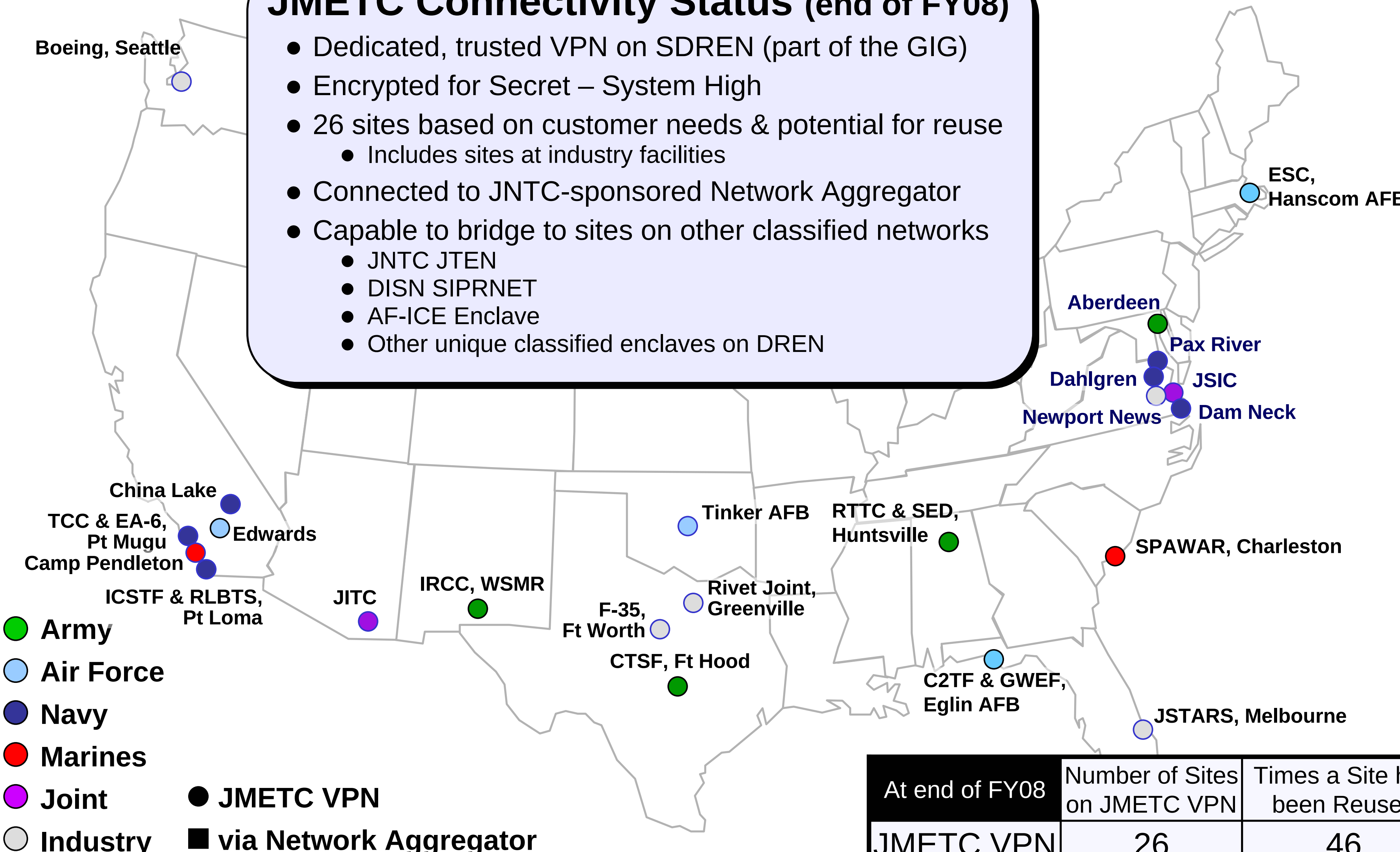
- ● JMETC VPN
- ■ via Network Aggregator

After this event	Number of Sites on JMETC VPN	Times a Site has been Reused
JMETC VPN	24+2	46

Projected JMETC Connectivity (at end of FY08)

JMETC Connectivity Status (end of FY08)

- Dedicated, trusted VPN on SDREN (part of the GIG)
- Encrypted for Secret – System High
- 26 sites based on customer needs & potential for reuse
  - Includes sites at industry facilities
- Connected to JNTC-sponsored Network Aggregator
- Capable to bridge to sites on other classified networks
  - JNTC JTEN
  - DISN SIPRNET
  - AF-ICE Enclave
  - Other unique classified enclaves on DREN



At end of FY08	Number of Sites on JMETC VPN	Times a Site has been Reused
JMETC VPN	26	46

In the First Year JMETC Has:

- Stood up the VPN
- Supported two major events
  - Four customers
  - Seven instances of site/security agreement reuse
- Aggregated three network enclaves
  - Leveraging Service established sites/security agreements when ever possible
- Begun event planning with four major acquisition programs
  - CVN-21, FCS, JSF, SIAP
  - Indicates that they each see value in JMETC
- Won the cooperative and collaborative support of the Services and Agencies
  - Our success is dependent on their future support
- Conducted the Distributed Test Infrastructure Study
  - Resulted in three gaps to be analyzed in three study tasks
    - Next slide

Distributed Test Infrastructure Studies

- FY07 Distributed Test Infrastructure Assessment, approved by the JCB, resulted in need for three studies:
  - **Task 1: Transition from IPv4 to IPv6 at test facilities and laboratories**
    - Scope: What is the modernization schedule of each of the Services to IPv6 at their test facilities and laboratories?
  - **Task 2: Applicability of Service-Oriented Architectures (SOA) to Distributed Testing Infrastructure**
    - Scope: When will SOAs be suitable to support distributed testing data management requirements?
      - What are the benefits of modernizing instrumentation to use a SOA for testing?
      - What are the benefits of modernizing distributed test tools to use a SOA for testing?
  - **Task 3: Test Infrastructure Required for Warfighting Systems using the Global Information Grid (GIG)**
    - Scope: What future instrumentation, distributed test tools, connectivity, and data management capabilities will be needed to conduct distributed tests to verify warfighting capabilities (in CT, DT, OT, etc.) are operating correctly with the GIG?
- Studies to be completed by April FY09

JMETC Program Points of Contact

JMETC Program Manager:	**Chip Ferguson** chip.ferguson@osd.mil 703-604-0350x138
JMETC Lead Systems Engineer:	**George Rumford** george.rumford@osd.mil 703-601-5233
JMETC Operations, Planning Support:	**Len Zimmermann** leonard.zimmermann.ctr@osd.mil 703-604-0350x141

JMETC Program Office Contact:

- E-mail: jmetc-feedback@jmetc.org
- Telephone: (703) 604-0350 ext. 0
- JMETC Website: www.jmetc.org – under construction
- JMETC Help Desk: www.jmetc.org – under construction

TENA Website: www.tena-sda.org

- Links to JMETC, Help Desk, and products

Backup

Summary

- Provide for the full spectrum of Joint testing, supporting many customers in many different Joint mission threads
- Being built based on current customer requirements
  - CVN-21, SIAP, FCS, JSF, MMA, NECC, DD1000, WWF
- Partnering with Service and Agency activities
  - Leveraging existing capabilities
- Working with JFCOM to develop a joint, multi-use test and training network infrastructure

The warfighter is the ultimate beneficiary with warfighting capabilities verified to work together

Background

- **March 2004** – SPG: "Joint Testing in Force Transformation"
  - Policy – *Developing and fielding joint force capabilities requires adequate, realistic test and evaluation in a joint operational context*
  - Direction – *DoD will provide new testing capabilities and institutionalize the evaluation of joint system effectiveness*
  - Action – DOT&E lead development of a Roadmap to define changes *to ensure that T&E is conducted in a joint environment and facilitates the fielding of joint capabilities*
- **November 2004** – DEPSECDEF approved Roadmap, validated SPG
- **December 2005** – Department directed stand-up of the Joint Mission Environment Test Capability (JMETC) Program Element under USD(AT&L)/ TRMC for execution
- **October 2006** – Establishment of JMETC Program Management Office in Crystal City, VA

JMETC is <1.5 years old

JMETC Benefits

- Provides Department-wide capability for:
  - Evaluation of a weapon system in a joint context
  - DT, OT, Interoperability Certification, Net-Ready KPP compliance testing, Joint Mission Capability Portfolio testing, etc.
  - Effectively and efficiently linking distributed test facilities
  - More robust testing earlier in the acquisition process
  - Improved system interoperability
- Provides test capability aligned with JNTC
  - Both use TENA architecture to integrate resources
  - Enables joint test and training
- Reduces time and cost by providing
  - Readily available, persistent connectivity with standing network security agreements
  - Common integration software for linking sites
  - Distributed test planning support tools
- Provides distributed test expertise

The corporate solution to distributed LVC Testing

The warfighter is the ultimate beneficiary with warfighting capabilities verified to work together

Combinatorial Testing:

Required Knowledge in a World Where Traversing Every Possible Path is Impossible

Dr. Mark J. Kiemele
Air Academy Associates

24th Annual National Test and Evaluation Conference
Palm Springs, CA
February 25, 2008

Introductions

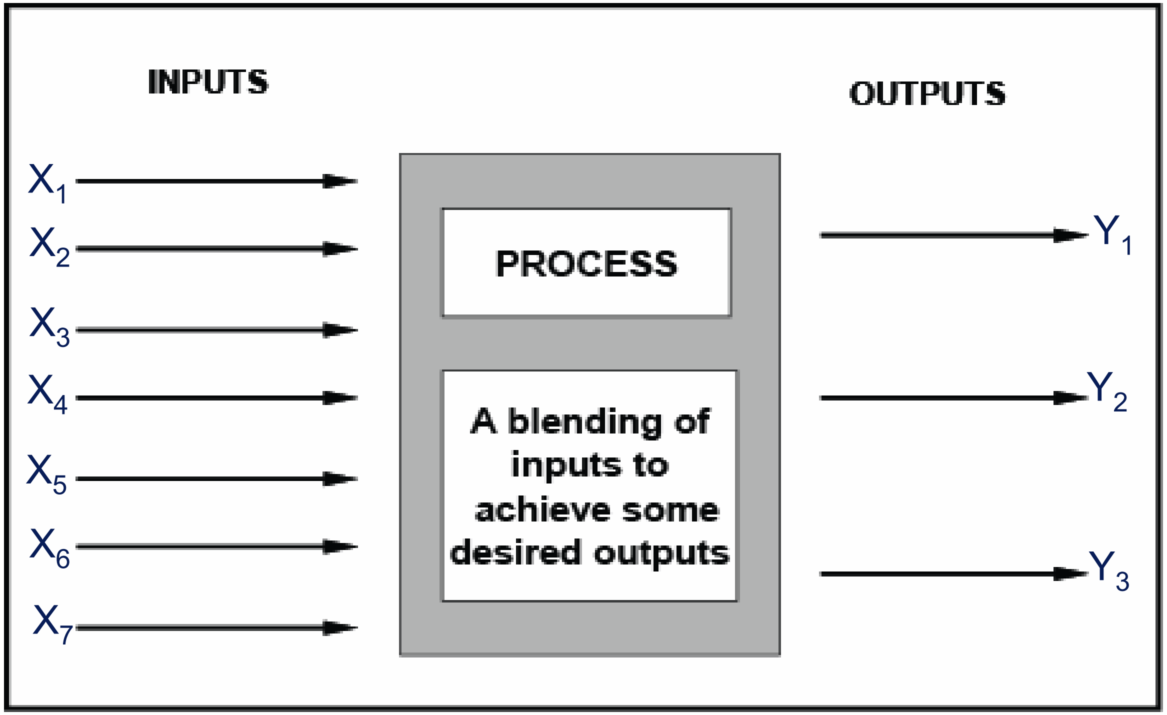
- **Name**
- **Organization**
- **Job Title/Duties**
- **Experience in T&E, Combinatorial Testing, etc.**

Agenda

- Some Basic Definitions
- Various Approaches to Testing Multiple Factors
- Design of Experiments (DOE): a Modern Approach to Combinatorial Testing
- Break
- Examples and Demonstration of a DOE
- Using DOE to Achieve Robust Designs
- DOE with Modeling and Simulation
- High Throughput Testing

Air Academy Associates
Simplify, Perfect, Innovate

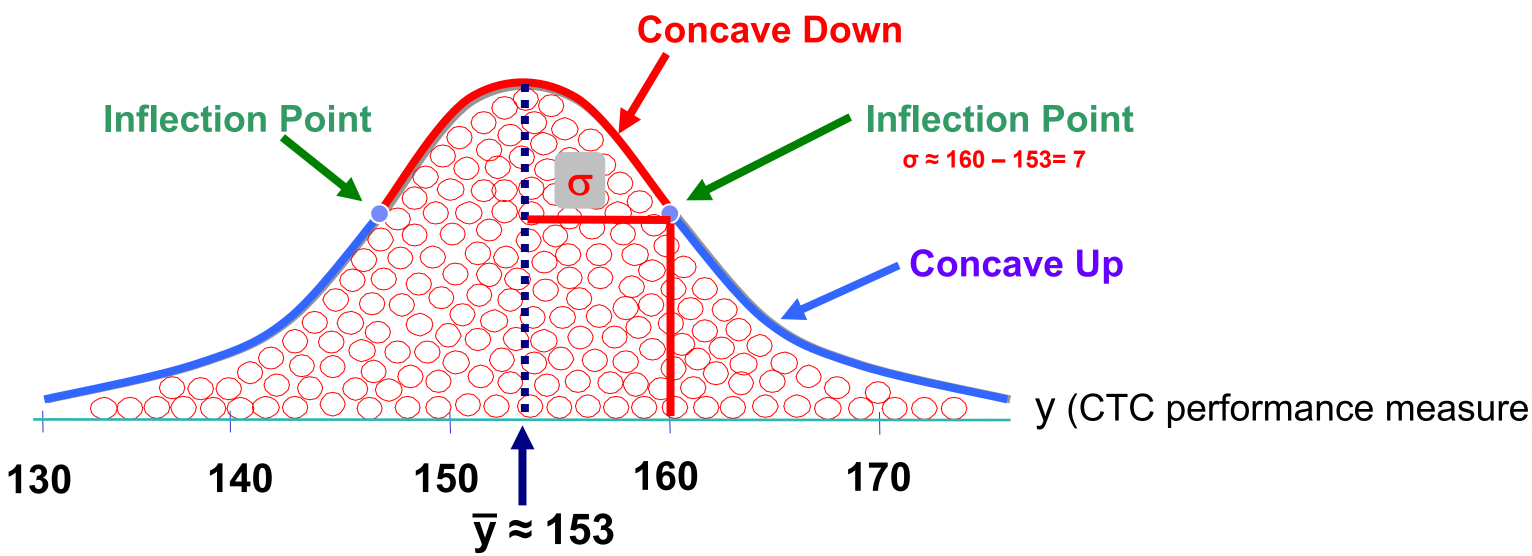
Definition of a Process



Graphical Meaning of $\bar{y}$ and σ

$\bar{y}$ = Average = Mean = Balance Point

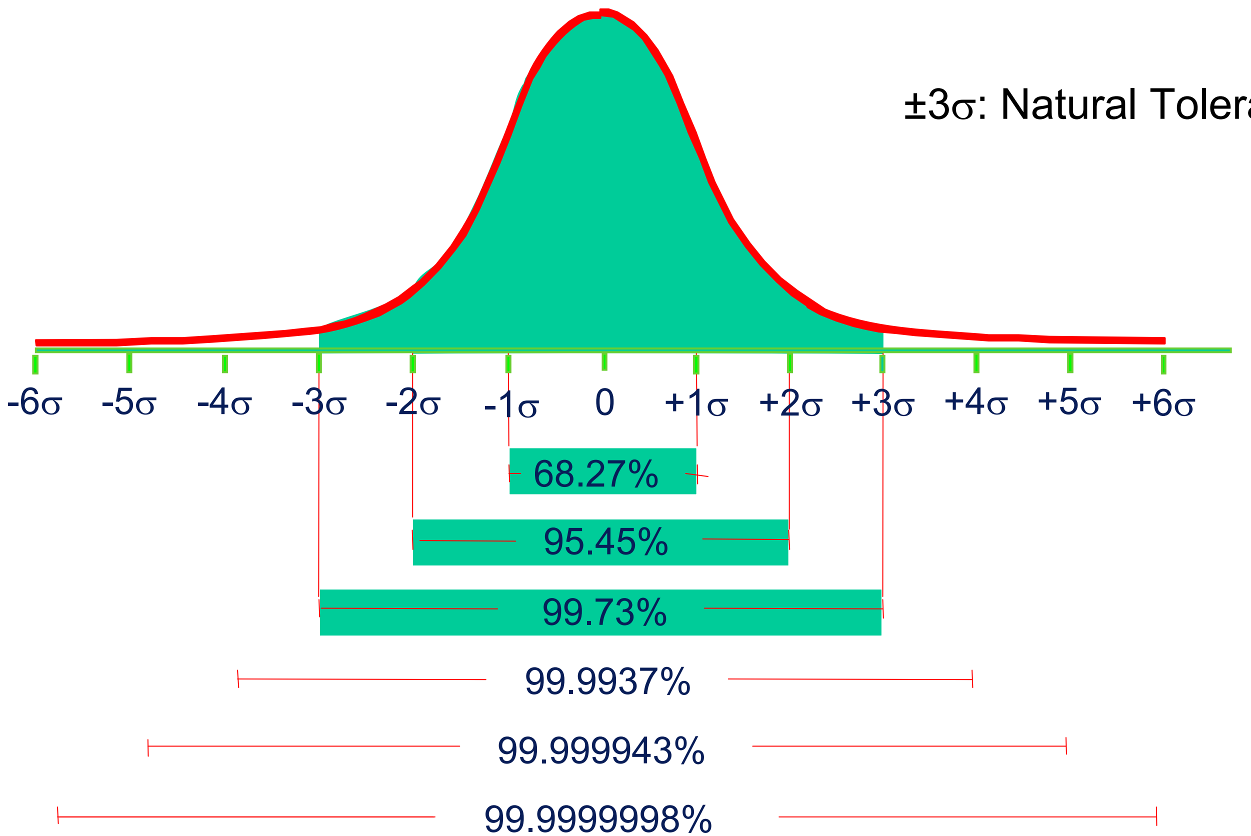
σ = Standard Deviation



σ ≈ average distance of points from the centerline

Air Academy Associates
Simplify, Perfect, Innovate

Graphical View of Variation



Typical Areas under the Normal Curve

Air Academy Associates
Simplify, Perfect, Innovate

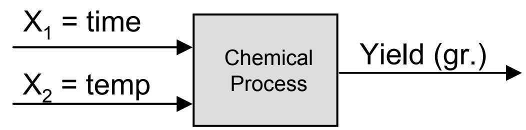
Approaches to Testing Multiple Factors

- **Traditional Approaches**
  - One Factor at a Time (OFAT)
  - Oracle (Best Guess)
  - All possible combinations (full factorial)

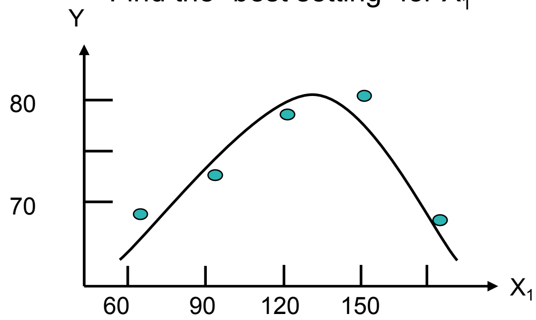
- **Modern Approach**
  - Statistically designed experiments (DOE) … full factorial plus other selected DOE designs, depending on the situation

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

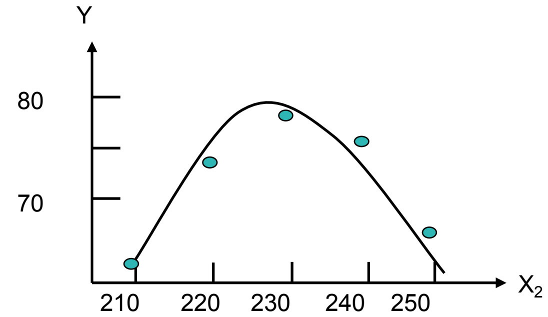
OFAT (One Factor at a Time)



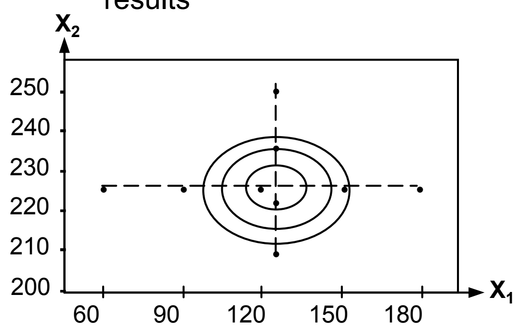
1. Hold X_2 constant and vary X_1
   Find the "best setting" for X_1



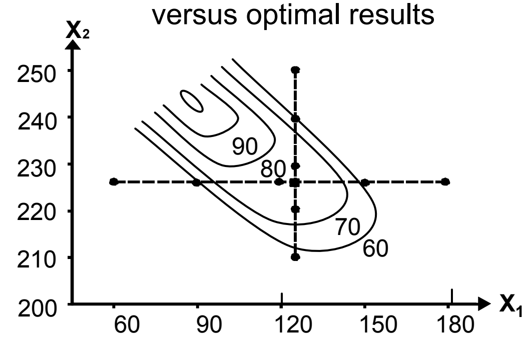
2. Hold X_1 constant at "best setting" and vary X_2.
   Find the "best setting" for X_2.



3. One factor at a time results



4. One factor at a time results versus optimal results



Simplify, Perfect, Innovate

Oracle (Best Guess)

W = Wetting Agent (1=.07 ml; 2=none)

P = Plasticizer (1=1ml; 2=none)

E = Environment (1=Ambient Mixing; 2=Semi-Evacuated)

C = Cement (1=Portland Type III; 2=Calcium Aluminate)

A = Additive (1=No Reinforcement; 2=Steel)

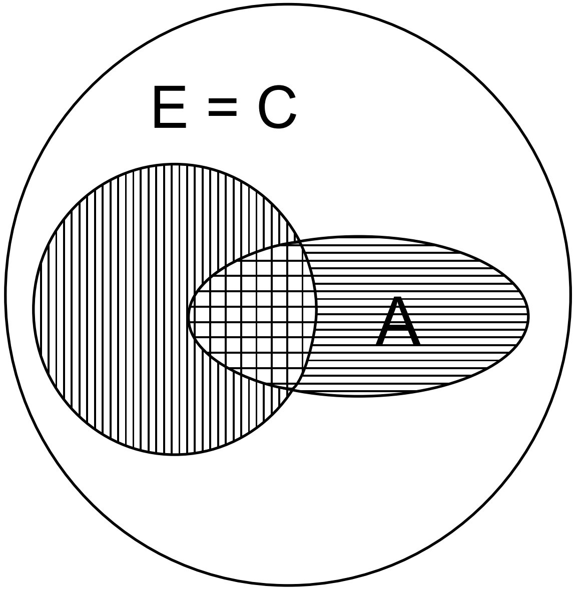
Y = Strength of Lunar Concrete

Run	W	P	E	C	A	Y
1	1	2	1	1	1	5
2	1	1	1	1	1	6
3	2	2	1	1	1	5
4	2	1	1	1	2	6
5	1	2	2	2	2	7
6	1	1	2	2	2	8
7	2	2	2	2	2	10
8	2	1	2	2	1	11

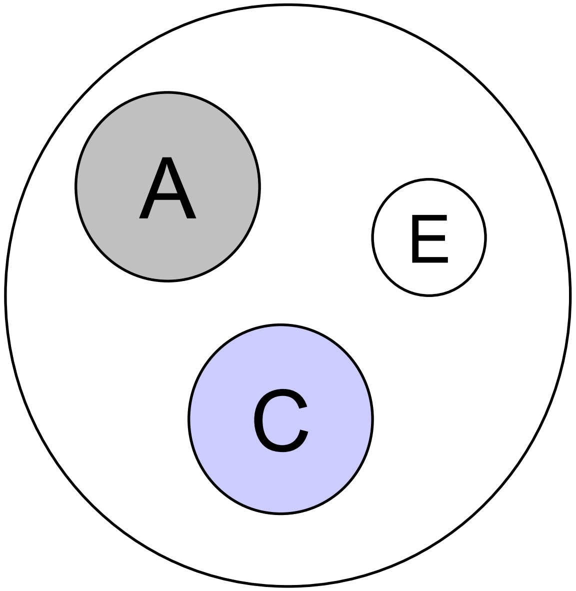
Air Academy Associates
Simplify, Perfect, Innovate

Evaluating the Effects of Variables on Y

What we have is:



What we need is a design to provide independent estimates of effects:



How do we obtain this independence of variables?

Air Academy Associates
Simplify, Perfect, Innovate

All Possible Combinations
(Full Factorial)

MATRIX FORM

Example 1:

A (2 levels)
B (2 levels)

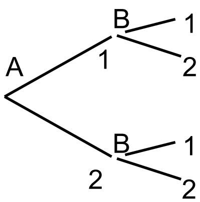
A	B
1	1
1	2
2	1
2	2

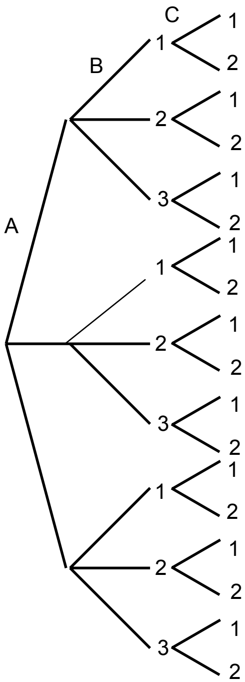
Example 2:

A (3 levels)
B (3 levels)
C (2 levels)

A	B	C
1	1	1
1	2	1
1	3	1
2	1	1
2	2	1
2	3	1
3	1	1
3	2	1
3	3	1
1	1	2
1	2	2
1	3	2
2	1	2
2	2	2
2	3	2
3	1	2
3	2	2
3	3	2

TREE DIAGRAM





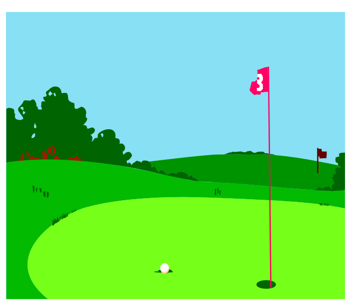
Design of Experiments (DOE)

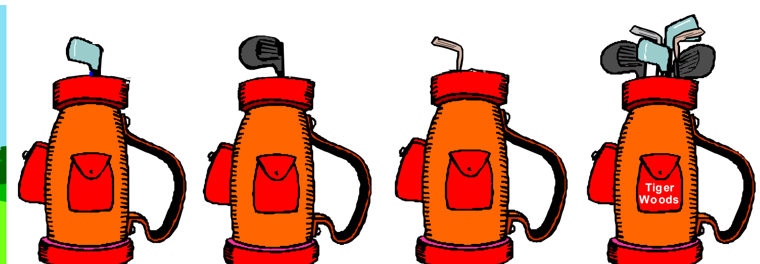
- An optimal data collection methodology
- “Interrogates” the process
- Used to identify important relationships between input and output factors
- Identifies important interactions between process variables
- Can be used to optimize a process
- Changes “I think” to “I know”

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Important Contributions From:

	TAGUCHI	SHAININ	CLASSICAL	BLENDED APPROACH
Loss Function	*			*
Emphasis on Variance Reduction	*			*
Robust Designs	*			*
KISS	*	*		*
Simple Significance Tests		*		*
Component Swapping		*		
Multivariate Charts		*		*
Modeling			*	*
Sample Size			*	*
Efficient Designs			*	*
Optimization			*	*
Confirmation	*			*
Response Surface Methods			*	*





Which bag would a world class golfer prefer?

Air Academy Associates
Simplify, Perfect, Innovate

Statistically Designed Experiments (DOE): Orthogonal or Nearly Orthogonal Designs

- FULL FACTORIALS (for small numbers of factors)
- FRACTIONAL FACTORIALS
- PLACKETT - BURMAN
- LATIN SQUARES
- HADAMARD MATRICES
- BOX - BEHNKEN DESIGNS
- CENTRAL COMPOSITE DESIGNS

PLACKETT - BURMAN, LATIN SQUARES, HADAMARD MATRICES: Taguchi Designs

SIMPLE DEFINITION OF TWO-LEVEL ORTHOGONAL DESIGNS

Run	Actual Settings			Coded Matrix			Responses
	(5, 10) A: Time	(70, 90) B: Temp	(100, 200) C: Press	(A) Time	(B) Temp	(C) Press	
1	5	70	100	-1	-1	-1	
2	5	70	200	-1	-1	+1	
3	5	90	100	-1	+1	-1	
4	5	90	200	-1	+1	+1	
5	10	70	100	+1	-1	-1	
6	10	70	200	+1	-1	+1	
7	10	90	100	+1	+1	-1	
8	10	90	200	+1	+1	+1	

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

The Beauty of Orthogonality:
independent evaluation of effects

A Full Factorial Design for 3 Factors, Each at 2 Levels

Run	A	B	C	AB	AC	BC	ABC
1	-	-	-	+	+	+	-
2	-	-	+	+	-	-	+
3	-	+	-	-	+	-	+
4	-	+	+	-	-	+	-
5	+	-	-	-	-	+	+
6	+	-	+	-	+	-	-
7	+	+	-	+	-	-	-
8	+	+	+	+	+	+	+

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Building a Fraction of the Full Factorial

Given the number of factors (k) = 4

i) The full factorial has $n = 2^4 = 16$ runs

ii) A $^1/_2$ fraction will have $n = 2^4/2 = 2^{4-1} = 8$ runs

STEP 1: Build an 8 run design for 3 factors: A, B, and C

STEP 2: Alias (perfectly confound) the 4th factor, D, with the highest order interaction in Step 1

STEP 3: Determine Aliasing (confounding) Pattern

Run	A 1	B 2	AB 3	C 4	AC 5	BC 6	D = ABC 7
1	-	-	+	-	+	+	-
2	-	-	+	+	-	-	+
3	-	+	-	-	+	-	+
4	-	+	-	+	-	+	-
5	+	-	-	-	-	+	+
6	+	-	-	+	+	-	-
7	+	+	+	-	-	-	-
8	+	+	+	+	+	+	+
Avg (-)							
Avg (+)							
Δ							
Δ / 2							

$\hat{Y} =$

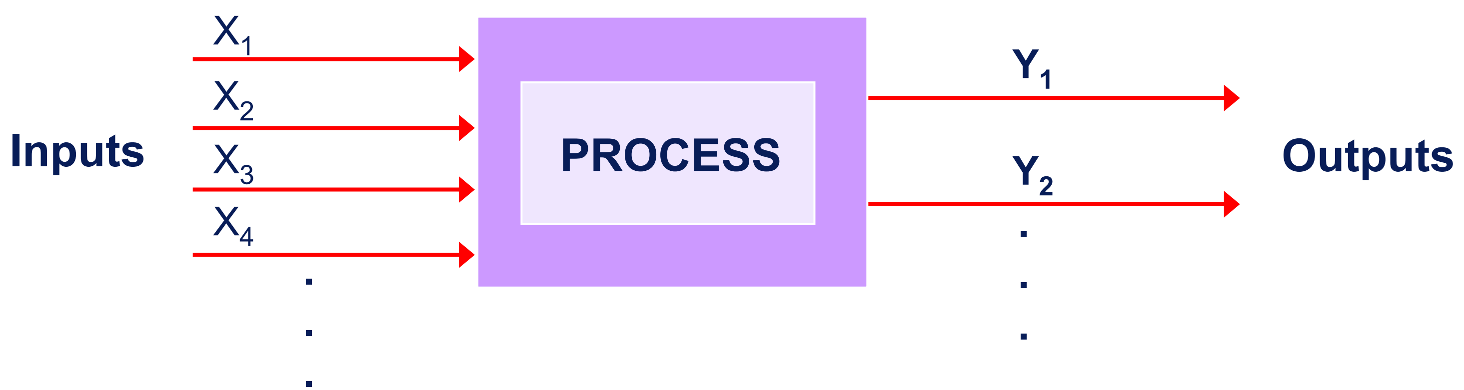
2^{5-1} DESIGN EXAMPLE

	Factors															Response		
Run	A	B	C	D	AB	AC	BC	AD	BD	CD	DE ABC	CE ABD	BE ACD	AE BCD	E ABCD	y_1	y_2	y_3
1																		
2																		
•																		
•																		
•																		
16																		

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

The Purpose of a Designed Experiment

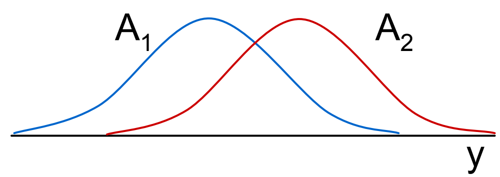
Purposeful changes of the inputs (factors) in order to observe corresponding changes in the output (response).



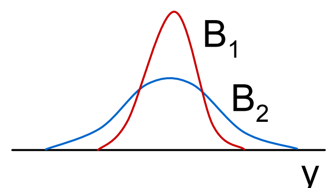
Run	X_1	X_2	X_3	X_4	Y_1	Y_2	. . . . . .	$\bar{Y}$	S_Y
1									
2									
3									
.									
.									

DOE Helps Determine How Inputs Affect Outputs

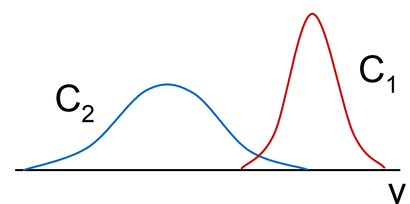
i) Factor A affects the average of y



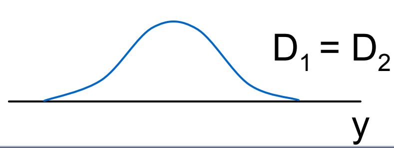
ii) Factor B affects the standard deviation of y



iii) Factor C affects the average and the standard deviation of y



iv) Factor D has no effect on y



KISS Guidelines for Choosing an Experimental Design

KISS - Keep It Simple Statistically

Source: Steve Schmidt
Mark Kiemele
Cass Grandone

PF → **Process flow diagram**

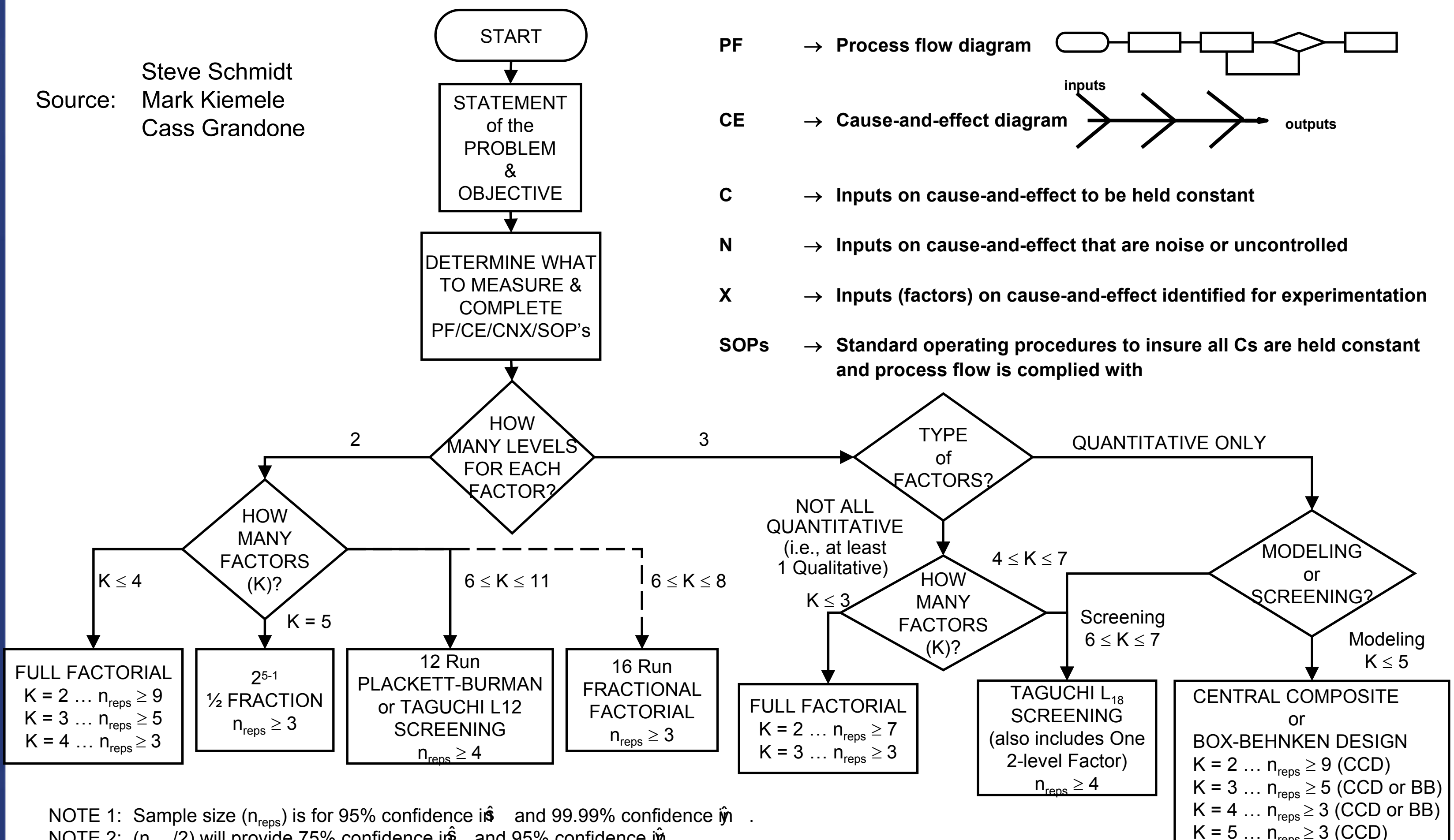
CE → **Cause-and-effect diagram** (inputs, outputs)

C → **Inputs on cause-and-effect to be held constant**

N → **Inputs on cause-and-effect that are noise or uncontrolled**

X → **Inputs (factors) on cause-and-effect identified for experimentation**

SOPs → **Standard operating procedures to insure all Cs are held constant and process flow is complied with**



NOTE 1: Sample size (n_{reps}) is for 95% confidence in $\hat{s}$ and 99.99% confidence in $\hat{y}$.
NOTE 2: (n_{reps}/2) will provide 75% confidence in $\hat{s}$ and 95% confidence in $\hat{y}$.
NOTE 3: The 12 Run Plackett-Burman or L12 is very sensitive to large numbers of interactions. If this is the case, you would be better off using the 16 Run Fractional Factorial or a smaller number of variables in 2 or more full factorial experiments.
NOTE 4: For more complete 2-level design options, see next page.

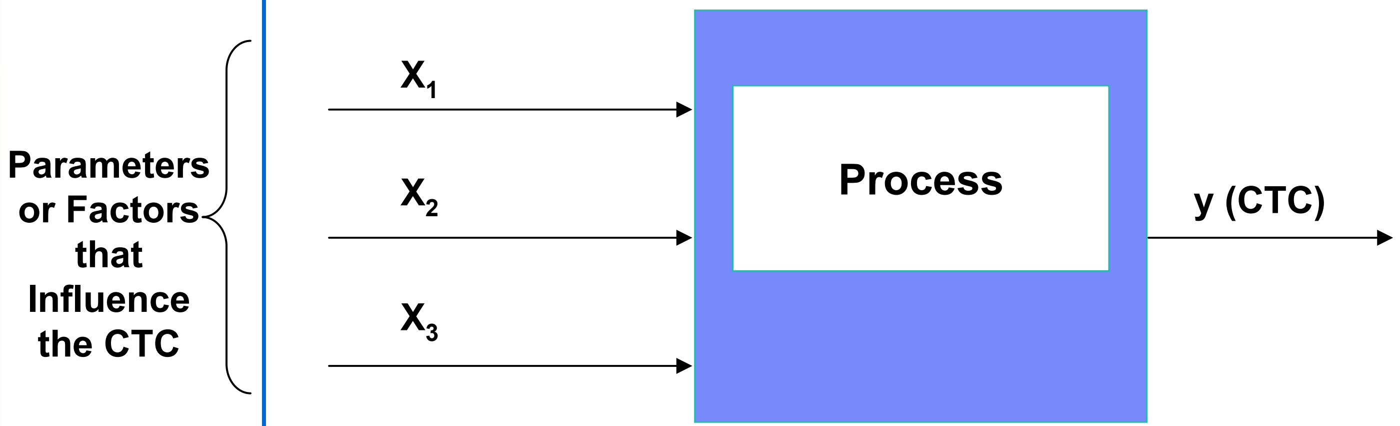
Simplify, Perfect, Innovate

Building a Screening Design

L_{12} Design											
Run	1	2	3	4	5	6	7	8	9	10	11
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	+	+	+	+	+	+
3	-	-	+	+	+	-	-	-	+	+	+
4	-	+	-	+	+	-	+	+	-	-	+
5	-	+	+	-	+	+	-	+	-	+	-
6	-	+	+	+	-	+	+	-	+	-	-
7	+	-	+	+	-	-	+	+	-	+	-
8	+	-	+	-	+	+	+	-	-	-	+
9	+	-	-	+	+	+	-	+	+	-	-
10	+	+	+	-	-	-	-	+	+	-	+
11	+	+	-	+	-	+	-	-	-	+	+
12	+	+	-	-	+	-	+	-	+	+	-

Simplify, Perfect, Innovate

Transfer Functions



$$\hat{y} = f_1(x_1, x_2, x_3)$$

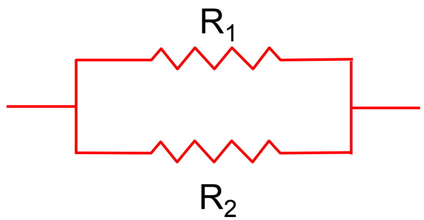
$$\hat{s} = f_2(x_1, x_2, x_3)$$

Where does the transfer function come from?

- **Exact transfer Function**
- **Approximations**
  - **DOE**
  - **Historical Data Analysis**
  - **Simulation**

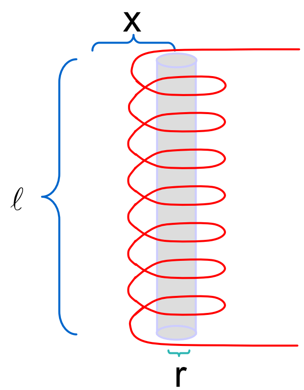
Exact Transfer Function

- Engineering Relationships
  - V = IR
  - F = ma



The equation for the impedance (Z) through this circuit is defined by:

$$Z = \frac{R_1 \cdot R_2}{R_1 + R_2}$$



The equation for magnetic force at a distance X from the center of a solenoid is:

$$H = \frac{NI}{2\ell}\left[\frac{.5\ell + x}{\sqrt{r^2 + (.5\ell + x)^2}} + \frac{.5\ell - x}{\sqrt{r^2 + (.5\ell - x)^2}}\right]$$

Where
- N : total number of turns of wire in the solenoid
- I : current in the wire, in amperes
- r : radius of helix (solenoid), in cm
- ℓ : length of the helix (solenoid), in cm
- x : distance from center of helix (solenoid), in cm
- H : magnetizing force, in amperes per centimeter

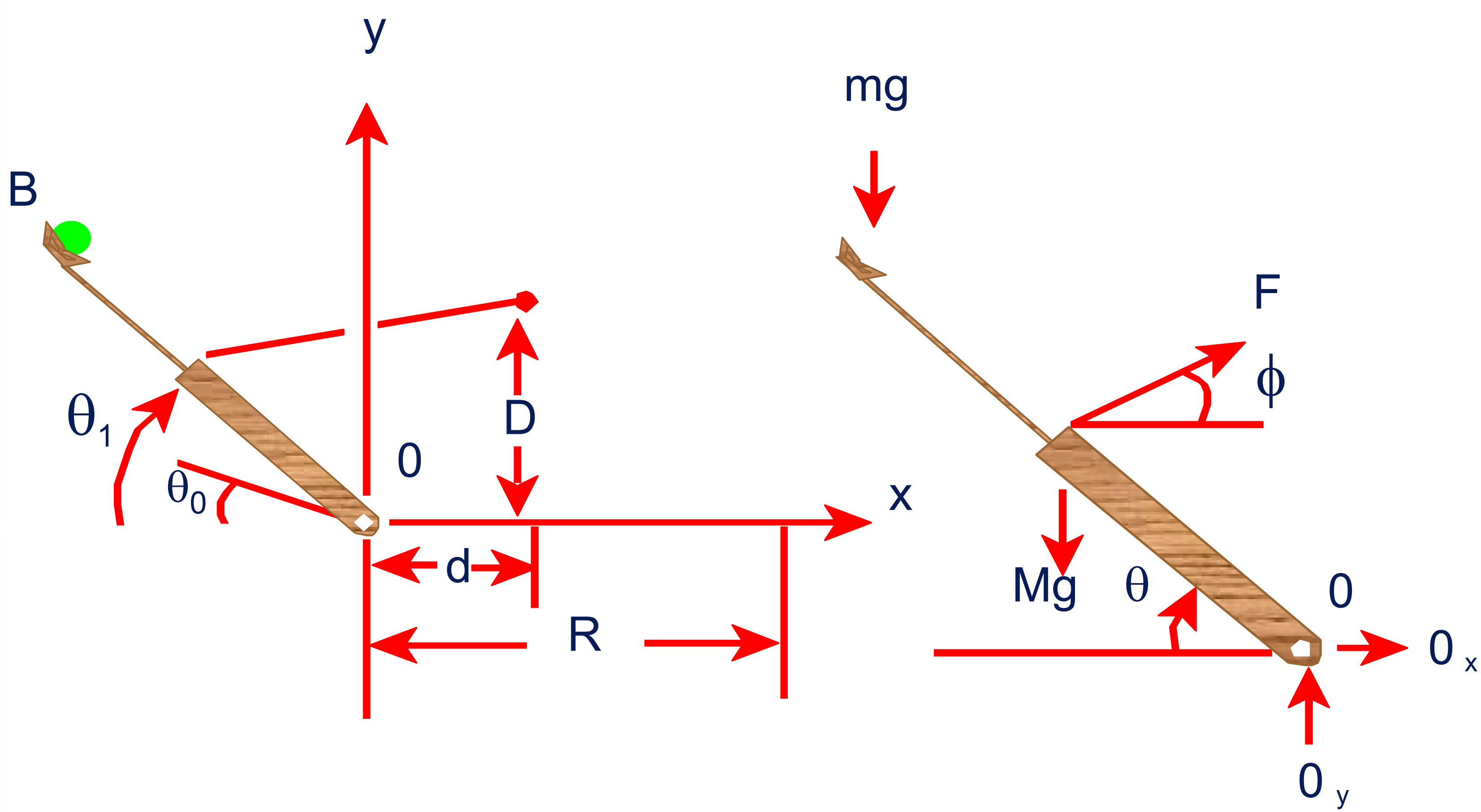
Air Academy Associates
Simplify, Perfect, Innovate

Catapulting Power into Test and Evaluation

Statapult® Catapult

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

The Theoretical Approach



The Theoretical Approach (cont.)

$$I_0\ddot{\theta} = r_F F(\theta)\sin\theta\cos\varphi - (Mgr_G + mgr_B)\sin\theta \qquad \tan\phi = \frac{D - r_F\sin\theta}{d + r_F\cos\theta},$$

$$\frac{1}{2}I_0\dot{\theta}^2 = r_F\int_{\theta_0}^{\theta} F(\theta)\sin\theta\cos\varphi\, d\theta - (Mgr_G + mgr_B)(\sin\theta - \sin\theta_0)$$

$$\frac{1}{2}I_0\dot{\theta}_1^2 = r_F\int_{\theta_0}^{\theta_1} F(\theta)\sin\theta\cos\varphi\, d\theta - (Mgr_G + mgr_B)(\sin\theta_1 - \sin\theta_0).$$

$$x = v_B\cos\left(\frac{\pi}{2} - \theta_1\right)t - \frac{1}{2}r_B\cos\theta_1 \qquad y = r_B\sin\theta_1 + v_B\sin\left(\frac{\pi}{2} - \theta_1\right)t - \frac{1}{2}gt^2.$$

$$r_B\sin\theta_1 + (R + r_B\cos\theta_1)\tan\left(\frac{\pi}{2} - \theta_1\right) - \frac{g}{2V_B^2}\,\frac{(R + r_B\cos\theta_1)^2}{\cos^2\left(\frac{\pi}{2} - \theta_1\right)} = 0.$$

$$\frac{gI_0}{4r_B}\,\frac{(R + r_B\cos\theta_1)^2}{\cos^2\left(\frac{\pi}{2} - \theta_1\right)\left[r_B\sin\theta_1 + (R + r_B\cos\theta_1)\tan\left(\frac{\pi}{2} - \theta_1\right)\right]}$$

$$= r_F\int_{\theta_0}^{\theta_1} F(\theta)\sin\theta\cos\phi\, d\theta - (Mgr_G + mgr_B)(\sin\theta_1 - \sin\theta_0).$$

AIR ACADEMY ASSOCIATES

Simplify, Perfect, Innovate

Statapult® DOE Demo
(The Empirical Approach)

	Actual Factors		Coded Factors			Response Values			
Run	**A**	**B**	**A**	**B**	**AB**	Y_1	Y_2	$\bar{Y}$	**S**
1	144	2	-1	-1	+1				
2	144	3	-1	+1	-1				
3	160	2	+1	-1	-1				
4	160	3	+1	+1	+1				
	Avg –								
	Avg +								
	Δ								

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Minimizing the # of Factor Changes

(GRAY CODE SEQUENCE)

Problem: If changing factor settings is time consuming and/or expensive, using a Gray Code sequence to determine the sequence of runs may be useful. A Gray Code sequence orders the runs so that only 1 factor setting changes between runs and the most difficult to change factors are changed less frequently.

16-Run Design

Run	A	B	C	D
1	-	-	-	-
2	-	-	-	+
3	-	-	+	-
4	-	-	+	+
5	-	+	-	-
6	-	+	-	+
7	-	+	+	-
8	-	+	+	+
9	+	-	-	-
10	+	-	-	+
11	+	-	+	-
12	+	-	+	+
13	+	+	-	-
14	+	+	-	+
15	+	+	+	-
16	+	+	+	+

Gray Code by Run #
1
2
4
3
7
8
6
5
13
14
16
15
11
12
10
9

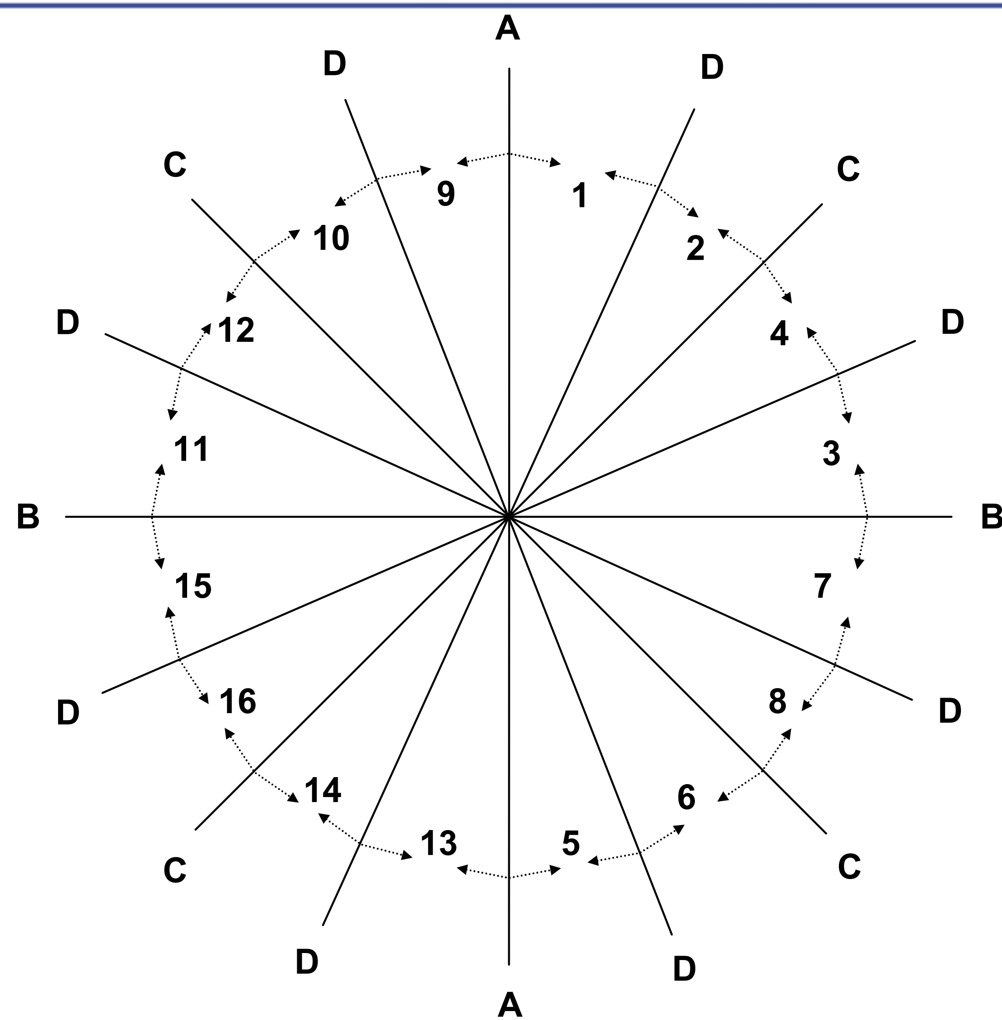
Cycling through the runs from top to bottom (or vice versa) will produce 15 changes:

- D will be changed 8 times.
- C will be changed 4 times.
- B will be changed 2 times.
- A will be changed 1 time.

Thus, the most difficult (or expensive) to change factors should be assigned to A, B, C, D, respectively.

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

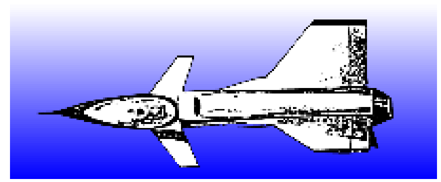
Test Sequence Generator



Gray Code Sequence Generator (Wheel)
by Run Number for 16 Runs and 4 Factors

Value Delivery: Reducing Time to Market for New Technologies

INPUT



OUTPUT

Pitch <) (0, 15, 30)

Roll <) (0, 15, 30)

W1F <) (-15, 0, 15)

W2F <) (-15, 0, 15)

W3F <) (-15, 0, 15)

Modeling Flight Characteristics of New 3-Wing Aircraft

Six Aero-Characteristics

- **Total # of Combinations = 3^5 = 243**
- **Central Composite Design: n = 30**

Patent Holder: Dr. Bert Silich

Central Composite Designs
(Box-Wilson Designs)

CCD for K=3 Factors

		FACTOR		
	Run	A	B	C
	1	-	-	-
	2	-	-	+
	3	-	+	-
F	4	-	+	+
	5	+	-	-
	6	+	-	+
	7	+	+	-
	8	+	+	+
	9	0	0	0
C	10	0	0	0
	11	0	0	0
	12	$-\alpha$	0	0
	13	$+\alpha$	0	0
A	14	0	$-\alpha$	0
	15	0	$+\alpha$	0
	16	0	0	$-\alpha$
	17	0	0	$+\alpha$

F = factorial portion

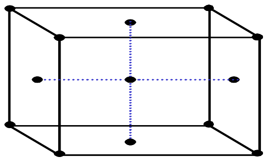
C = centerpoint portion

A = axial portion

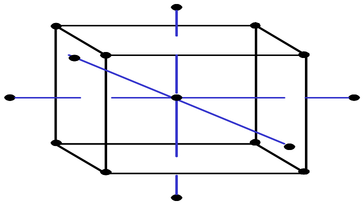
AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Suggested Values for α and Center Points
(Central Composite Designs)

- **Face-centered Design (α = 1)**
  - Hard limits (restrictions) on factor settings
  - Cannot take factor settings beyond ±1 (coded values)
  - Predictions made within the "cube"
  - Recommended number of center points = 2



- **Spherical Design ($\alpha = \sqrt{k}$)**
  Rotatable Design ($\alpha = (n_F)^{1/4}$)
  - No hard limits (constraints) on factor settings
  - Able to go beyond ±1 coded settings
  - Predictions slightly beyond the "cube" (in case the optimum lies just outside)
  - Orthogonality can be an issue, so a larger number of center points is recommended (between 3 and 6)
    - n_F is the number of runs in the factorial part of the design
    - k is the number of factors



Simplify, Perfect, Innovate

Aircraft Equations

C_L = .233 + .008(P)^2 + .255(P) + .012(R) - .043(WD1) - .117(WD2) + .185(WD3) + .010(P)(WD3) - .042(R)(WD1) + .035(R)(WD2) + .016(R)(WD3) + .010(P)(R) - .003(WD1)(WD2) - .006(WD1)(WD3)

C_D = .058 + .016(P)^2 + .028(P) - .004(WD1) - .013(WD2) + .013(WD3) + .002(P)(R) - .004(P)(WD1) - .009(P)(WD2) + .016(P)(WD3) - .004(R)(WD1) + .003(R)(WD2) + .020(WD1)^2 + .017(WD2)^2 + .021(WD3)^2

C_Y = -.006(P) - .006(R) + .169(WD1) - .121(WD2) - .063(WD3) - .004(P)(R) + .008(P)(WD1) - .006(P)(WD2) - .008(P)(WD3) - .012(R)(WD1) - .029(R)(WD2) + .048(R)(WD3) - .008(WD1)^2

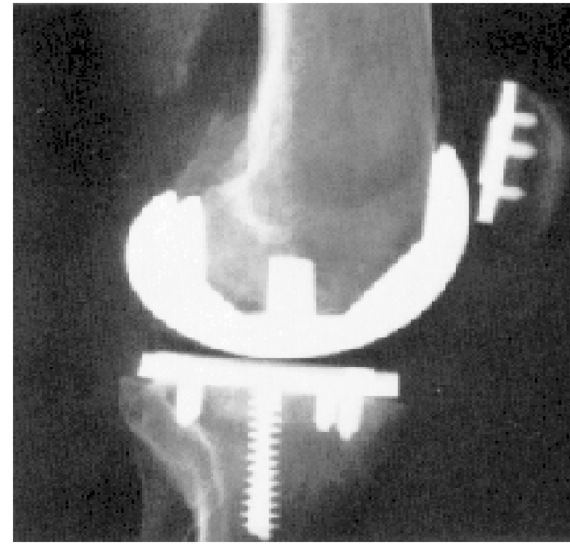
C_M = .023 - .008(P)^2 + .004(P) - .007(R) + .024(WD1) + .066(WD2) - .099(WD3) - .006(P)(R) + .002(P)(WD2) - .005(P)(WD3) + .023(R)(WD1) - .019(R)(WD2) - .007(R)(WD3) + .007(WD1)^2 - .008(WD2)^2 + .002(WD1)(WD2) + .002(WD1)(WD3)

C_{YM}= .001(P) + .001(R) - .050(WD1) + .029(WD2) + .012(WD3) + .001(P)(R) - .005(P)(WD1) - .004(P)(WD2) - .004(P)(WD3) + .003(R)(WD1) + .008(R)(WD2) - .013(R)(WD3) + .004(WD1)^2 + .003(WD2)^2 - .005(WD3)^2

C_e = .003(P) + .035(WD1) + .048(WD2) + .051(WD3) - .003(R)(WD3) + .003(P)(R) - .005(P)(WD1) + .005(P)(WD2) + .006(P)(WD3) + .002(R)(WD1)

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Fusing Titanium and Cobalt-Chrome



Air Academy Associates

Simplify, Perfect, Innovate

Courtesy Rai Chowdhary

Hierarchical Transfer Functions

$$Y = \text{Gross Margin} = \frac{\text{Gross Profit}}{\text{Gross Revenue}}$$

$$Y = f(y_1, y_2, y_3, y_4, y_5, y_6)$$

$$= \frac{(\overset{y_1}{\text{Rev}_{\text{equip}}} - \overset{y_2}{\text{COG}}) + (\overset{y_3}{\text{Rev}_{\text{post sales}}} - \overset{y_4}{\text{Cost}_{\text{post sales}}}) + (\overset{y_5}{\text{Rev}_{\text{fin}}} - \overset{y_6}{\text{Cost}_{\text{fin}}})}{y_1 + y_3 + y_5}$$

$$\overset{y_4}{\text{Cost}_{\text{post sales}}} = f(\overset{x_1}{\text{field cost}}, \overset{x_2}{\text{remote services}}, \overset{x_3}{\text{suppliers}})$$

$$x_1 = f(\text{direct labor, freight, parts, depreciation})$$

Air Academy Associates
Simplify, Perfect, Innovate

Modeling The Drivers of Turnover

① External Market Factors
(Local Labor Market Conditions)

- Local Unemployment Rate
- Local Employment Alternatives
- Company's Market Share

② Organizational Characteristics
and Practices

- Supervisor Stability
- Lateral / Upward Mobility
- Layoff Climate

③ Employee Attributes

- Time Since Last Promotion
- Education Level
- Job Stability History

Process of Deciding to Stay / Leave

Turnover Rate

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

DOE "Market Research" Example

Suppose that, in the auto industry, we would like to investigate the following automobile attributes (i.e., factors), along with accompanying levels of those attributes:

A: Brand of Auto:	-1 = foreign		+1 = domestic
B: Auto Color:	-1 = light	0 = bright	+1 = dark
C: Body Style:	-1 = 2-door	0 = 4-door	+1 = sliding door/hatchback
D: Drive Mechanism:	-1 = rear wheel	0 = front wheel	+1 = 4-wheel
E: Engine Size:	-1 = 4-cylinder	0 = 6-cylinder	+1 = 8-cylinder
F: Interior Size:	-1 ≤ 2 people	0 = 3-5 people	+1 ≥ 6 people
G: Gas Mileage:	-1 ≤ 20 mpg	0 = 20-30 mpg	+1 ≥ 30 mpg
H: Price:	-1 ≤ $20K	0 = $20-$40K	+1 ≥ $40K

In addition, suppose the respondents chosen to provide their preferences to product profiles are taken based on the following demographic:

J: Age:	-1 ≤ 25 years old	+1 ≥ 35 years old
K: Income:	-1 ≤ $30K	+1 ≥ $40K
L: Education:	-1 < BS	+1 ≥ BS

Air Academy Associates
Simplify, Perfect, Innovate

DOE “Market Research” Example (cont.)

Question: **Choose the best design for evaluating this scenario**

Answer: **L_{18} design with attributes A - H in the inner array and factors J, K, and L in the outer array, resembling an L_{18} robust design, as shown below:**

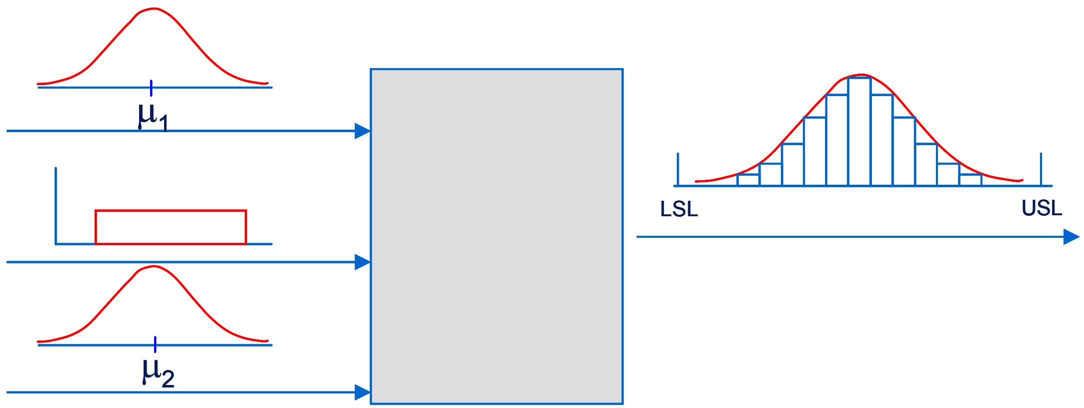
									L	-	+	-	+	-	+	-	+		
									K	-	-	+	+	-	-	+	+		
									J	-	-	-	-	+	+	+	+		
Run*	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**		y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	$\bar{y}$	s
1	-	-	-	-	-	-	-	-											
2	-	-	0	0	0	0	0	0											
3	-	-	+	+	+	+	+	+											
4	-	0	-	-	0	0	+	+											
5	-	0	0	0	+	+	-	-											
6	-	0	+	+	-	-	0	0											
7	-	+	-	0	-	+	0	+											
8	-	+	0	+	0	-	+	-											
9	-	+	+	-	+	0	-	0											
10	+	-	-	+	+	0	0	-											
11	+	-	0	-	-	+	+	0											
12	+	-	+	0	0	-	-	+											
13	+	0	-	0	+	-	+	0											
14	+	0	0	+	-	0	-	+											
15	+	0	+	-	0	+	0	-											
16	+	+	-	+	0	+	-	0											
17	+	+	0	-	+	-	0	+											
18	+	+	+	0	-	0	+	-											

Segmentation of the population or

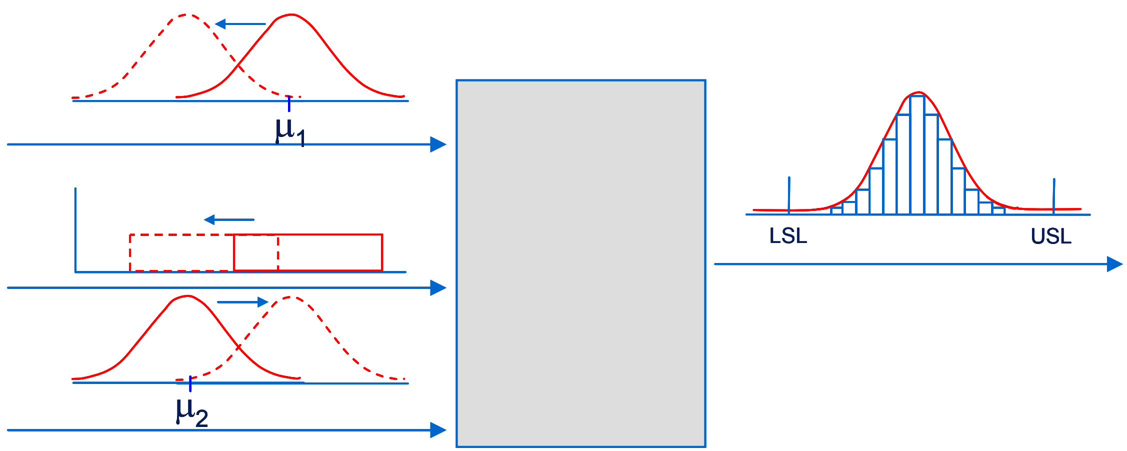
<u>Respondent Profiles</u>

* 18 different product profiles

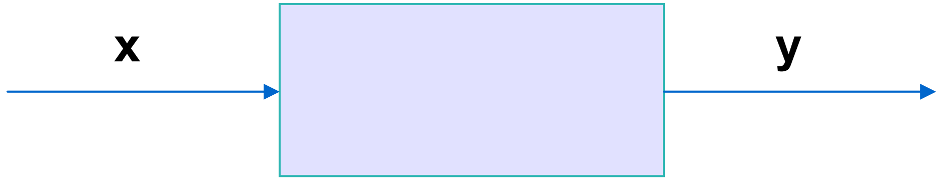
Robust Design



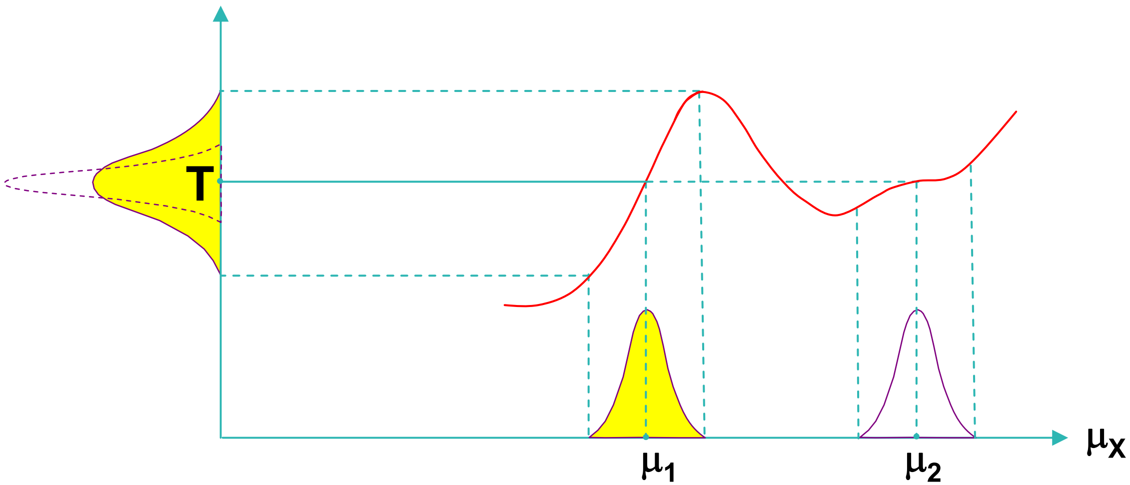
Process of finding the optimal location parameters (i.e., means) of the input variables to minimize dpm.



Why Robust Design?

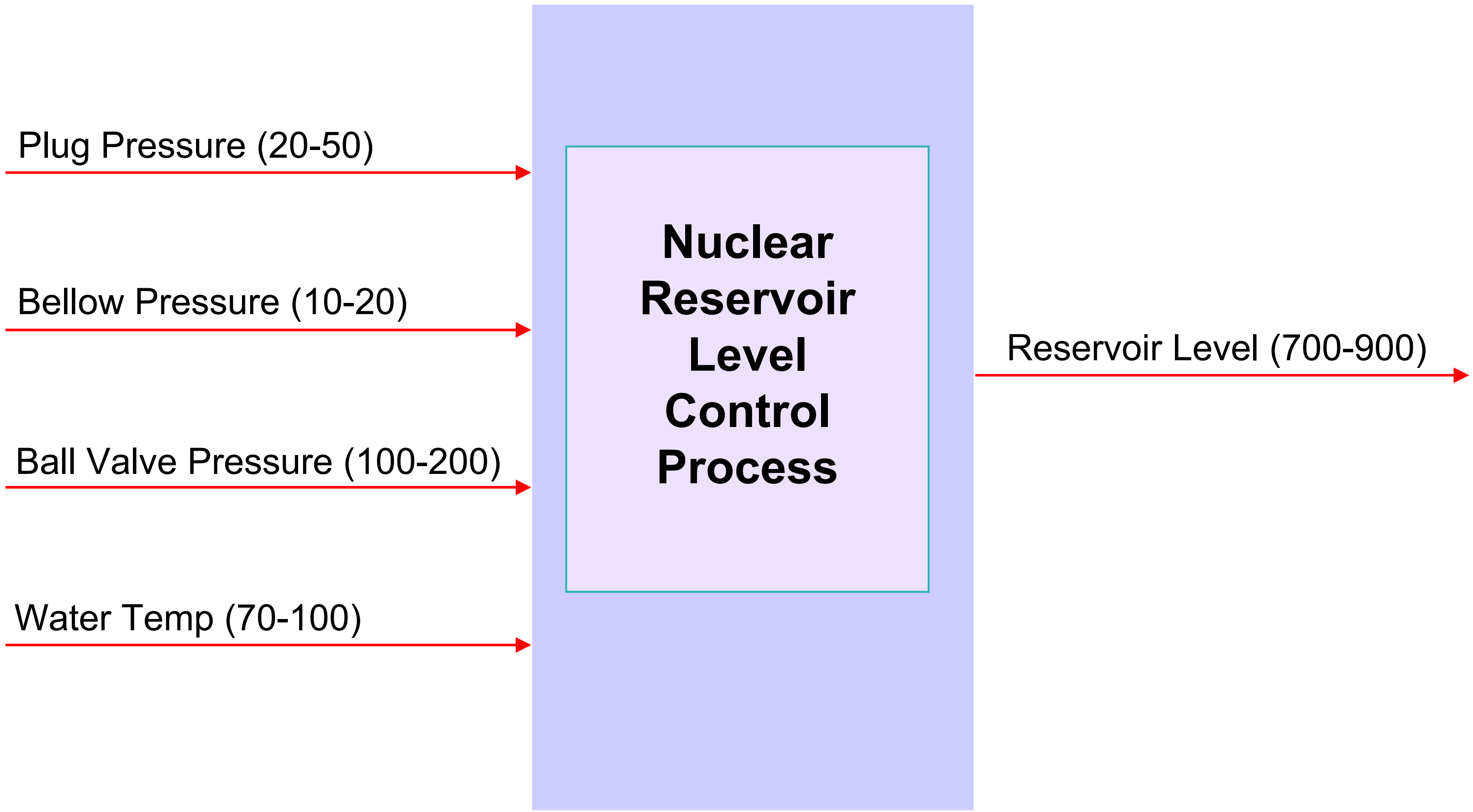


One Input



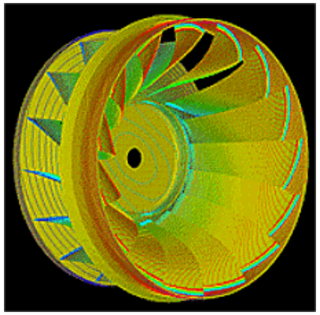
If μ_X varies, should we select μ_1 or μ_2 to hit y = T?

Robust (Parameter) Design Simulation Example



Examples of Simulation and High Performance Computing (HPC)

Power

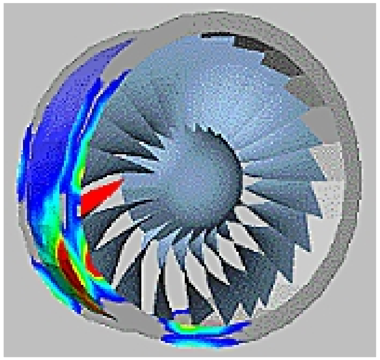


Simulation of stress and vibrations of turbine assembly for use in nuclear power generation

Automotive

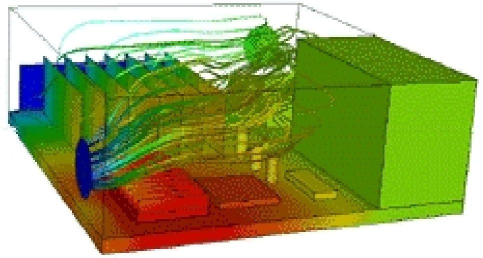
Simulation of underhood thermal cooling for decrease in engine space and increase in cabin space and comfort

Aerospace



Evaluation of dual bird-strike on aircraft engine nacelle for turbine blade containment studies

Electronics



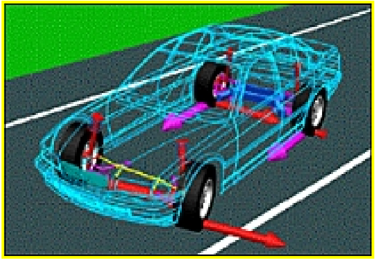
Evaluation of cooling air flow behavior inside a computer system chassis

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Examples of Computer Aided Engineering (CAE) and Simulation Software

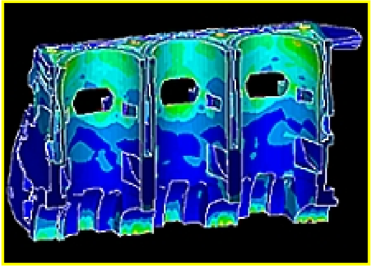
Mechanical motion: **Multibody kinetics and dynamics**

- **ADAMS®**
- **DADS**



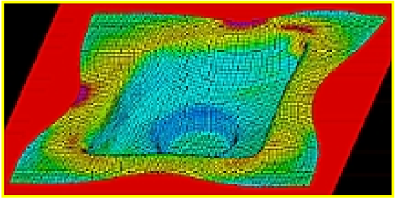
Implicit Finite Element Analysis: **Linear and nonlinear statics, dynamic response**

- **MSC.Nastran™, MSC.Marc™**
- **ANSYS®**
- **Pro MECHANICA**
- **ABAQUS® Standard and Explicit**
- **ADINA**



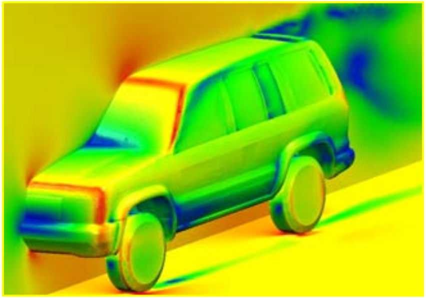
Explicit Finite Element Analysis : **Impact simulation, metal forming**

- **LS-DYNA**
- **RADIOSS**
- **PAM-CRASH®, PAM-STAMP**



General Computational Fluid Dynamics: **Internal and external flow simulation**

- **STAR-CD**
- **CFX-4, CFX-5**
- **FLUENT®, FIDAP™**
- **PowerFLOW®**



Air Academy Associates
Simplify, Perfect, Innovate

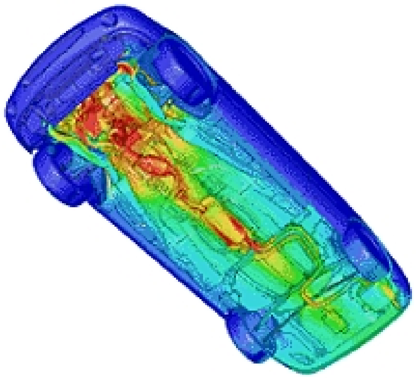
Examples of Computer Aided Engineering (CAE) and Simulation Software (cont.)

Preprocessing: Finite Element Analysis and Computational Fluid Dynamics mesh generation

- ICEM-CFD
- Gridgen
- Altair® HyperMesh®
- I-deas®
- MSC.Patran
- TrueGrid®
- GridPro
- FEMB
- ANSA

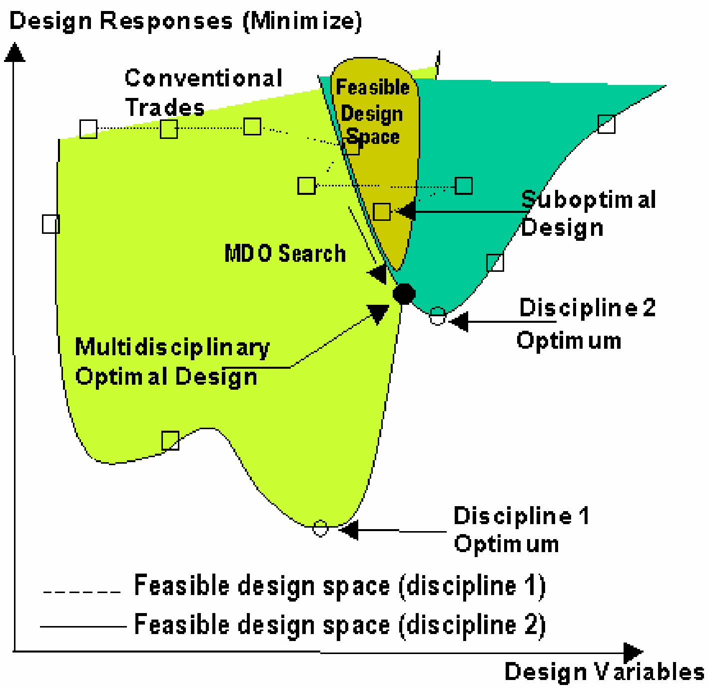
Postprocessing: Finite Element Analysis and Computational Fluid Dynamics results visualization

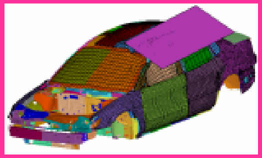
- Altair® HyperMesh®
- I-deas
- MSC.Patran
- FEMB
- EnSight
- FIELDVIEW
- ICEM CFD Visual3 2.0 (PVS)
- COVISE



AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Multidisciplinary Design Optimization (MDO): A Design Process Application





- CFD
- Structures
- Performance
- Controls
- Cost

- NVH
- Safety
- Durability
- Controls Stability
- Cost

Key Elements of MDO

- Massive Computational Problem;
- Solution by decomposition effective for complex systems;
- Multiprocessor computing simplifies MDO solutions conceptually & enables solutions previously intractable;
- Aids in the management of the design process.

Mastery of interactions between the disciplines (or, subsystems) is as important as the methods & tools used within a single discipline

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Latin Hypercube Sampling

- Method to populate the design space when using deterministic simulation models or when many variables are involved.

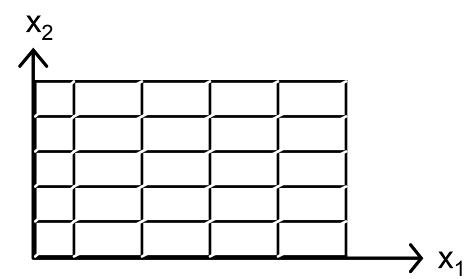
- Design space has k variables (or dimensions).

  Ex: Assume k = 2

- Suppose a sample of size n is to be taken; Stratify the design space into n^k cells.

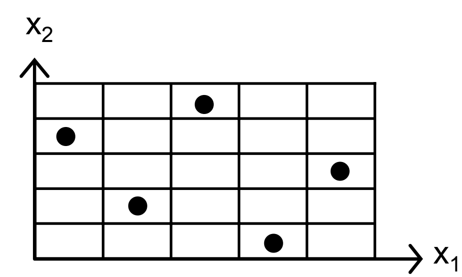
  Ex: Assume n = 5; $n^k = 5^2 = 25$

  Note: there are n strata for each of the k dimensions.



- Each of the n points is sampled such that each marginal strata is represented only once in the sample.

  Note: each sample point has its own unique row and column.



Simplify, Perfect, Innovate

Applying Modeling and Simulation to Automotive Vehicle Design

IDENTIFY CTCs, CDPs → Many, Many x's → **SCREENING DESIGN (DOE PRO)** → The critical few CDP's

Examples of CTCs:

NASTRAN RADIOSS MADYMO

Integrated processes with high fidelity CAE analyses on HPC servers

Examples of Critical Design Parameters (CDPs or Xs):

y_1 = weight of vehicle

y_2 = cost of vehicle

Safety CTCs with constraints specified by FMVSS (Federal Motor Vehicle Safety Standards)

- y_3 = frontal head impact
- y_4 = frontal chest impact
- y_5 = toe board intrusion
- y_6 = hip deflection
- y_7 = rollover impact
- y_8 = side impact

RADIOSS
DYNA
MADYMO

no federal requirements on these CTCs

- y_9 = internal aerodynamics (airflow)
- y_{10} = external aerodynamics (airflow)

CFD

- y_{11} = noise
- y_{12} = vibration (e.g., steering wheel)
- y_{13} = harshness (e.g., over bumps, shocks)
- y_{14} = durability (at 100K miles)

NASTRAN

x_1 = roof panel material

x_2 = roof panel thickness

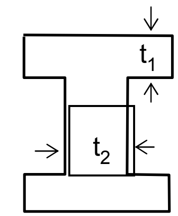
x_3 = door pillar dimensions ⇒ i beam

x_4 = shape/geometry

x_5 = windshield glass

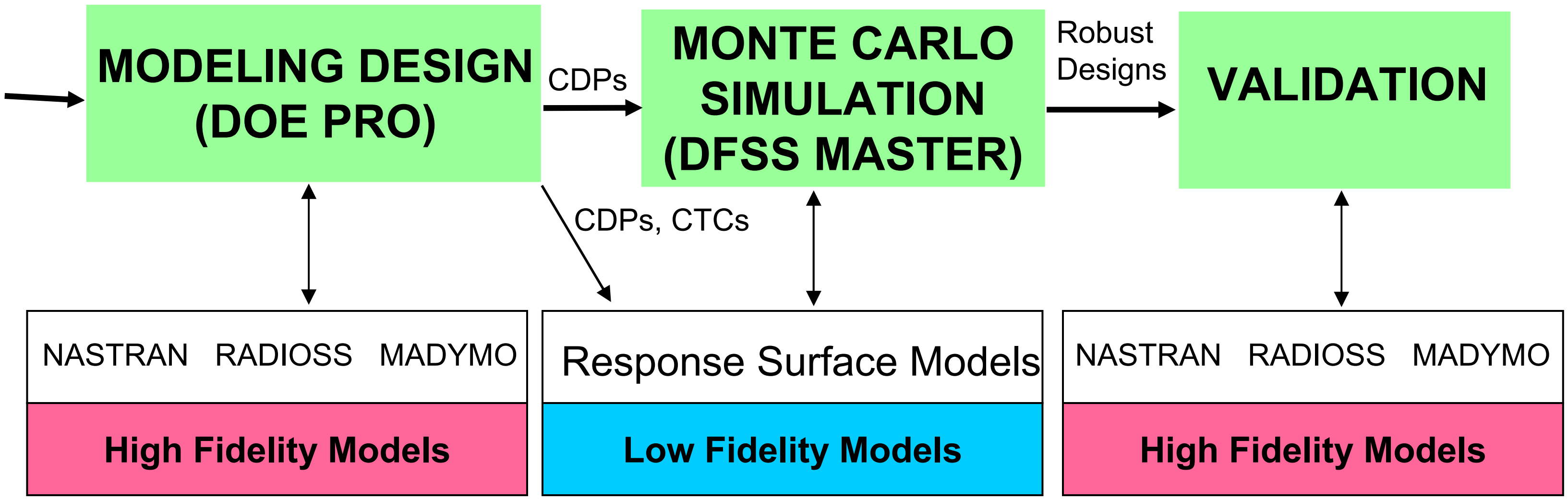
x_6 = hood material, sizing and thickness

x_7 = under hood panel material, sizing and thickness



Simplify, Perfect, Innovate

Applying Modeling and Simulation to Automotive Vehicle Design (cont.)



Air Academy Associates
Simplify, Perfect, Innovate

Introduction to High Throughput Testing (HTT)

- A recently developed technique based on combinatorics
- Used to test myriad combinations of many factors (typically qualitative) where the factors could have many levels
- Uses a minimum number of runs or combinations to do this
- Software (e.g., ProTest) is needed to select the minimal subset of all possible combinations to be tested so that all n-way combinations are tested.
- HTT is not a DOE technique, although the terminology is similar
- A run or row in an HTT matrix is, like DOE, a combination of different factor levels which, after being tested, will result in a successful or failed run
- HTT has its origins in the pharmaceutical business where in drug discovery many chemical compounds are combined together (combinatorial chemistry) at many different strengths to try to produce a reaction.
- Other industries are now using HTT, e.g., software testing, materials discovery, interoperability testing, IT (see IT example on next page)

Air Academy Associates
Simplify, Perfect, Innovate

HTT Example

- An IT function in a company wanted to test all 2-way combinations of a variety of computer configuration-related options or levels to see if they would function properly together.
- Here are the factors with each of their options:

Motherboards (5)	:	Gateway, ASUS, Micronics, Dell, Compaq
RAM (3)	:	128 MB, 256 MB, 512 MB
BIOS (3)	:	Dell, Award, Generic
CD (3)	:	Generic, Teac, Sony
Monitor (5)	:	Viewsonic, Sony, KDS, NEC, Generic
Printer (3)	:	HP, Lexmark, Cannon
Voltage (2)	:	220, 110
Resolution (2)	:	800x600, 1024x768

- How many total combinations are there?
- What is the minimum number of these combinations we will have to test (and which ones are they) in order to determine if every 2-way combination (e.g., Dell Bios with Teac CD) will indeed work properly together?
- To answer this question, we used Pro-Test software. The answer is 25 runs and those 25 combinations are shown on the next page.

Air Academy Associates
Simplify, Perfect, Innovate

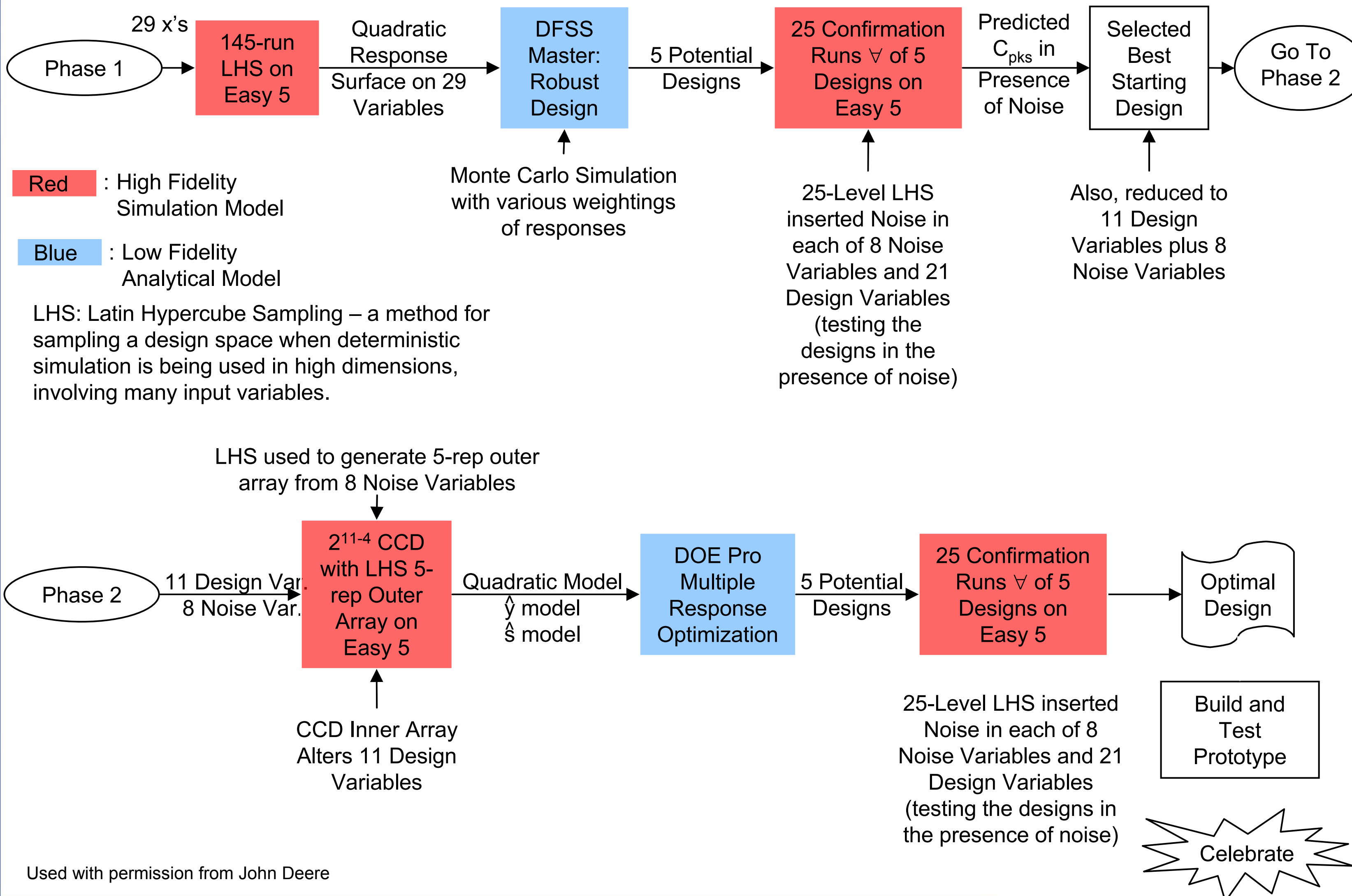
High Throughput Testing (HTT)

(for all two-way combinations)

	5 Levels	3 Levels	3 Levels	3 Levels	5 Levels	3 Levels	2 Levels	2 Levels
	Motherboard	**RAM**	**BIOS**	**CD**	**Monitor**	**Printer**	**Voltage**	**Resolution**
Case 1	ASUS	256 MB	Dell	Generic	Viewsonic	Lexmark	110 V	800 x 600
Case 2	Compaq	512 MB	Dell	Teac	Sony	HP	220 V	1024 x 768
Case 3	Gateway	128 MB	Generic	Sony	KDS	Cannon	220 V	800 x 600
Case 4	Dell	128 MB	Award	Teac	NEC	Cannon	110 V	1024 x 768
Case 5	Micronics	256 MB	Generic	Teac	Generic	Lexmark	220 V	1024 x 768
Case 6	Gateway	256 MB	Award	Sony	Sony	HP	110 V	1024 x 768
Case 7	Micronics	512 MB	Award	Generic	Viewsonic	Cannon	220 V	1024 x 768
Case 8	ASUS	512 MB	Generic	Teac	KDS	HP	220 V	1024 x 768
Case 9	Compaq	128 MB	Award	Generic	Generic	HP	110 V	800 x 600
Case 10	Micronics	512 MB	Generic	Teac	Sony	Lexmark	110 V	800 x 600
Case 11	Dell	256 MB	Award	Generic	KDS	Lexmark	110 V	1024 x 768
Case 12	Gateway	512 MB	Dell	Sony	Generic	Lexmark	110 V	1024 x 768
Case 13	Compaq	256 MB	Generic	Sony	Viewsonic	Cannon	220 V	1024 x 768
Case 14	ASUS	128 MB	Dell	Sony	NEC	Cannon	220 V	800 x 600
Case 15	Micronics	128 MB	Dell	Sony	KDS	Lexmark	220 V	800 x 600
Case 16	Gateway	128 MB	Generic	Teac	Viewsonic	HP	110 V	800 x 600
Case 17	Dell	128 MB	Dell	Sony	Sony	Cannon	110 V	1024 x 768
Case 18	ASUS	256 MB	Award	Sony	Generic	Cannon	220 V	1024 x 768
Case 19	Compaq	512 MB	Dell	Sony	NEC	Lexmark	110 V	800 x 600
Case 20	Gateway	256 MB	Generic	Generic	NEC	Cannon	220 V	800 x 600
Case 21	Micronics	512 MB	Generic	Teac	NEC	HP	220 V	800 x 600
Case 22	ASUS	256 MB	Generic	Generic	Sony	HP	110 V	800 x 600
Case 23	Dell	512 MB	Generic	Sony	Viewsonic	HP	220 V	1024 x 768
Case 24	Compaq	256 MB	Dell	Generic	KDS	Cannon	220 V	1024 x 768
Case 25	Dell	128 MB	Generic	Sony	Generic	HP	110 V	800 x 600

AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Example of Iterative Approach to Modeling and Simulation to Optimize Transmission Performance



Used with permission from John Deere

Technologies Used on Transmission Project

- **High Throughput Testing (HTT)**

  To generate a minimal number of test cases; in this scenario, 11 combinations of 29 variables that would allow testing all two-way combinations on Easy 5. This made running the Easy 5 simulator much easier, without interruption.

- **DFSS Master: for Robust Design and Expected Value Analysis (Monte Carlo Techniques)**

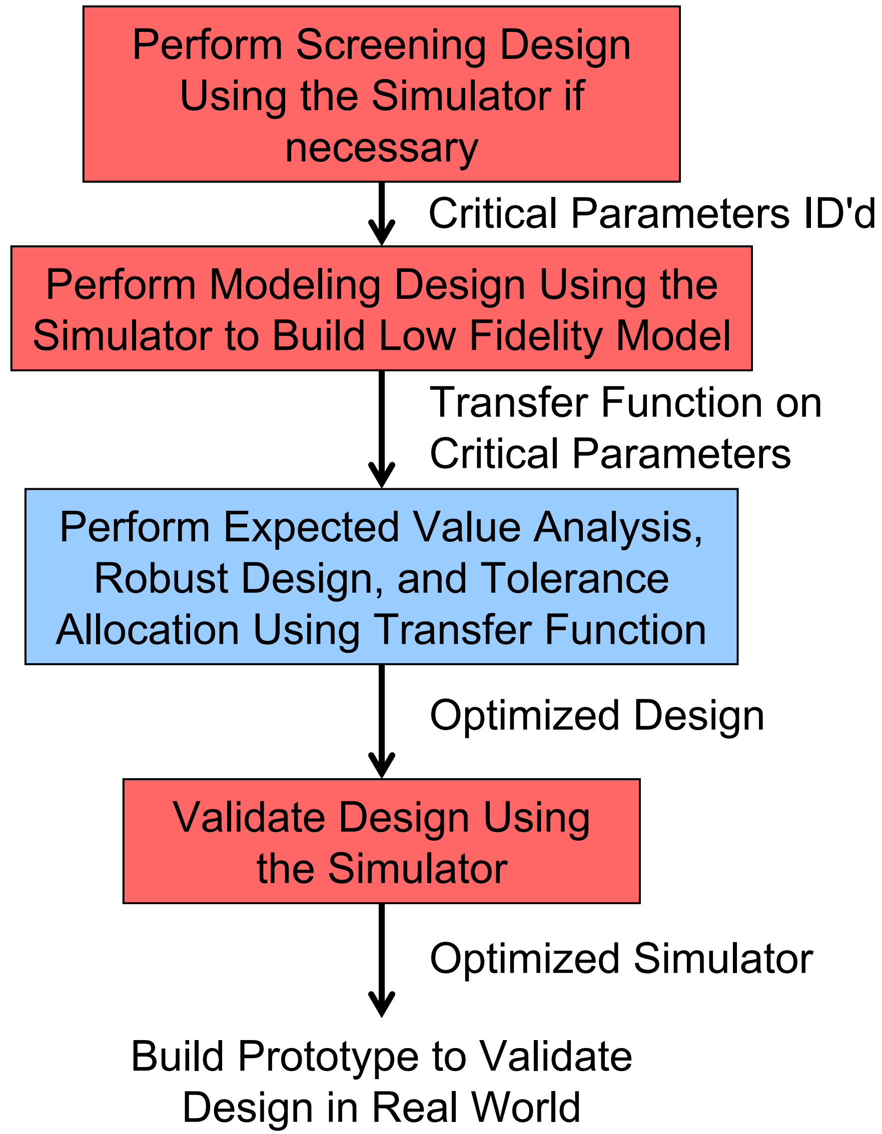
- **Highly Orthogonal Latin Hypercube Sampling**

  To populate the design space with test cases which are highly orthogonal. Typically used with deterministic simulation to screen out the CDPs and also to use modeling DOEs on the simulator to generate transfer functions which characterize the simulator

- **DOE PRO: for Multiple Response Optimization**

Air Academy Associates
Simplify, Perfect, Innovate

Summary of "Modeling the Simulator"



AIR ACADEMY ASSOCIATES
Simplify, Perfect, Innovate

Environments Where Simulation and Modeling Is Beneficial

- A high number of design variables
- A substantial number of design subsystems and engineering disciplines
- Interdependency and interaction between the subsystems and variables
- Multiple response variables
- Need to characterize the system at a higher level of abstraction
- Time and/or space must be compressed

Air Academy Associates
Simplify, Perfect, Innovate

Key Take-Aways

Simplify, Perfect, Innovate

For More Information, Please Contact

Mark J. Kiemele

Air Academy Associates, LLC

1650 Telstar Drive, Ste 110

Colorado Springs, CO 80920

Toll Free: (800) 748-1277 or (719) 531-0777

Facsimile: (719) 531-0778

Email: aapa@airacad.com

Website: www.airacad.com

Air Academy Associates

Simplify, Perfect, Innovate

Air Academy Associates

Simplify, Perfect, Innovate

referentia

Live, Virtual, & Constructive Simulation Use for Unmanned Vehicle Requirements and Test & Evaluation

Gary S Kollmorgen, Sr. Business Program Manager

Contents

Contents

T&E/M&S Context

DOT&E Policy Memo (4 June 2002)

- **…we must continue to focus on, "…the real system, in the real environment, with the real operator…"**

…however…

- **Models should help us predict performance throughout the mission space**
- **Models should help us design tests to maximize our learning and optimally apply our resources**
- **Models (stimulators) should help us replicate the environment during test to realistically stress the system under test**

Thomas P. Christie
Former Director,
Operational Test and Evaluation

More T&E/M&S Context

Modeling and Simulation in T&E

- Modeling and Simulation (M&S) is integral to and inseparable from T&E in support of acquisition. For T&E, M&S is an essential and proven tool. Each military department has extensive guidelines for use of M&S in acquisition and in T&E. These guidelines are intended to supplement other such resources.

  - Defense Acquisition Guidebook

- Appropriate use of accredited models and simulation shall support DT&E, IOT&E, and LFT&E.

  - DoD Instruction 5000.2

Contents

Some Context

National Defense Authorization Act FY 2001

- "It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that – by 2010, one-third of the operational deep strike aircraft of the Armed Forces are unmanned; and by 2015, one third of the operational ground combat vehicles of the Armed Forces are unmanned."

INDEX – Intelligent Decision Exploration

Focusing on

- Mission test & planning support for unmanned systems in ground unit protection scenarios
- Mission test & rehearsal for unmanned systems using Live, Virtual, and Constructive (LVC) M&S
- Overall T&E of unmanned systems especially with LVC M&S

For use by the Planner / Warfighter

Unmanned Vehicles: Ground Side

JBC2S

TAGS UGV

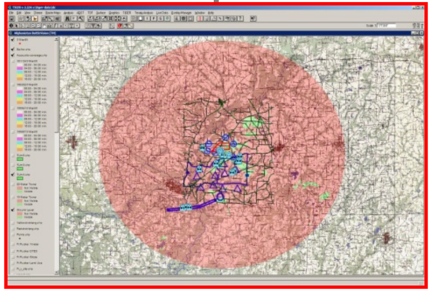
C2 Vehicle

AN/PPS-5D
GSR

BAIS

SeaFLIR

MPR Tool



RSS w/Sensor Suite

Unmanned Ground Vehicle Control using Joint Battlespace Command & Control System (JBC2S)

Lay Out Route Points

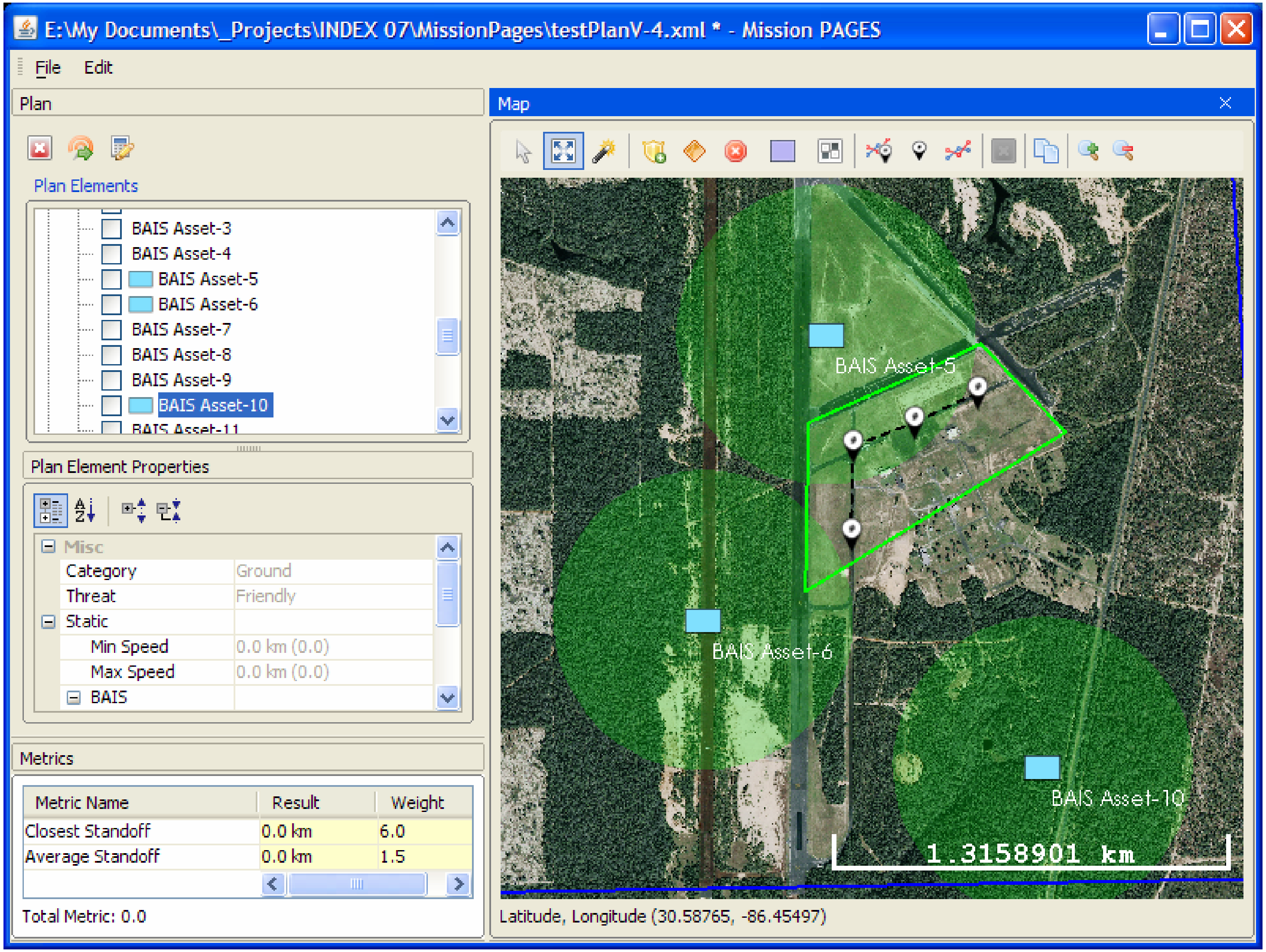
Control & Monitor

JBC2S

◆Based on:

- Mobile Detection Assessment Response System (MDARS)
- Multiple Resource Host Architecture (MRHA)
- Multi-Robot Operator Control Unit (MOCU)

Mission PAGES



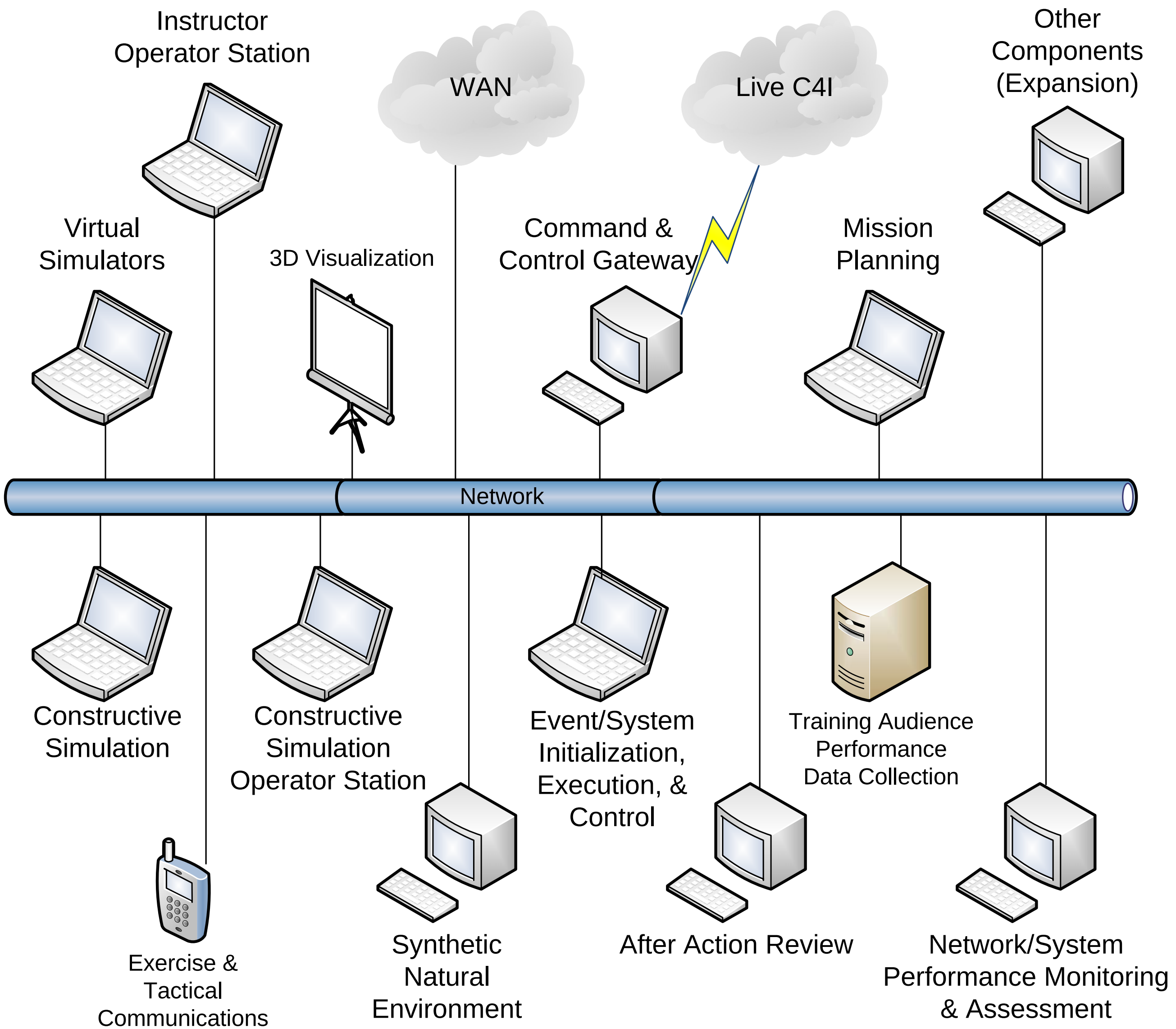
Mission Planning and Graphical Editing System

Current Capability

- **Assist Military Planners**
  - Quickly create deployment plans for multiple UVs in response to a new unit protection threat.
  - Evaluate unit protection plans w/CONOPS-oriented metrics
- **“What if” planning and evaluation**
  - Effects of changing deployment patterns
  - Effects of degraded sensors

Contents

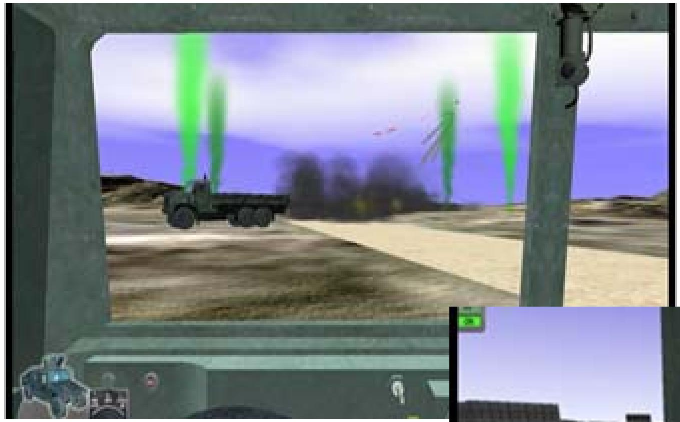
Notional Architecture



Distributed M&S

- **Robust capabilities exist today**
  - Computer Generated Entities (Constructive)
    - JSAF (Navy, JFCOM), JCATS (LLNL), OneSAF (Army), VRForces (Commercial)
    - Users: Army/Navy/Air Force (T&E, Training), Joint (Experimentation, CONOPS, and Training)
  - C4I connectivity
    - Use real world systems to control simulated assets
    - Joint LVC Data Translator, SIMPLE, others
  - Visualization
    - Really too numerous to mention
  - Standards based communication protocols
    - Distributed Interactive Simulation (DIS)
    - High Level Architecture (HLA)
    - Voice over Internet Protocol (VoIP)

Virtual Simulators



Driver View

Driver View - Internal

Typical Virtual Simulator

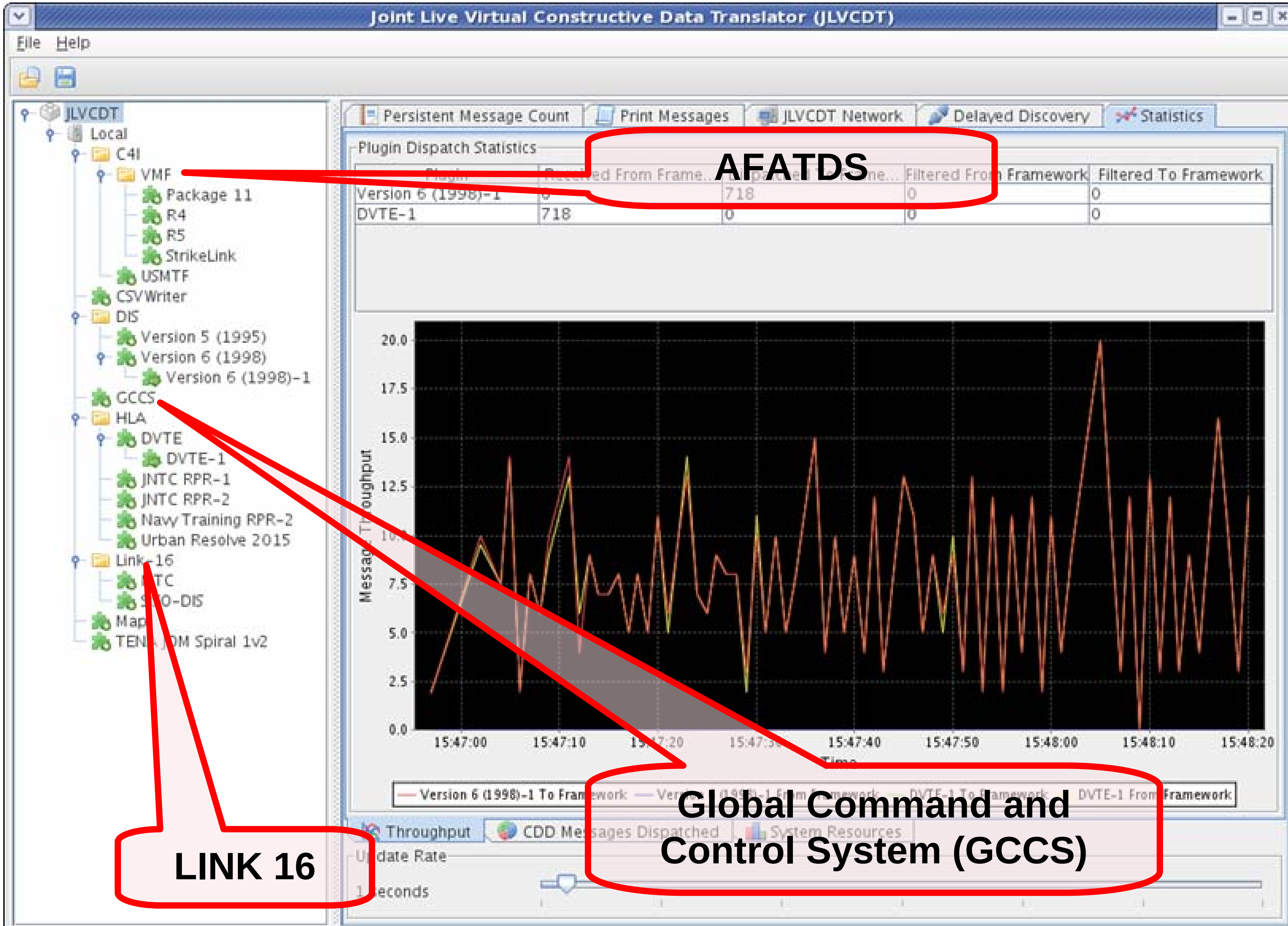
Gunner View

GOTS & COTS SOLUTIONS

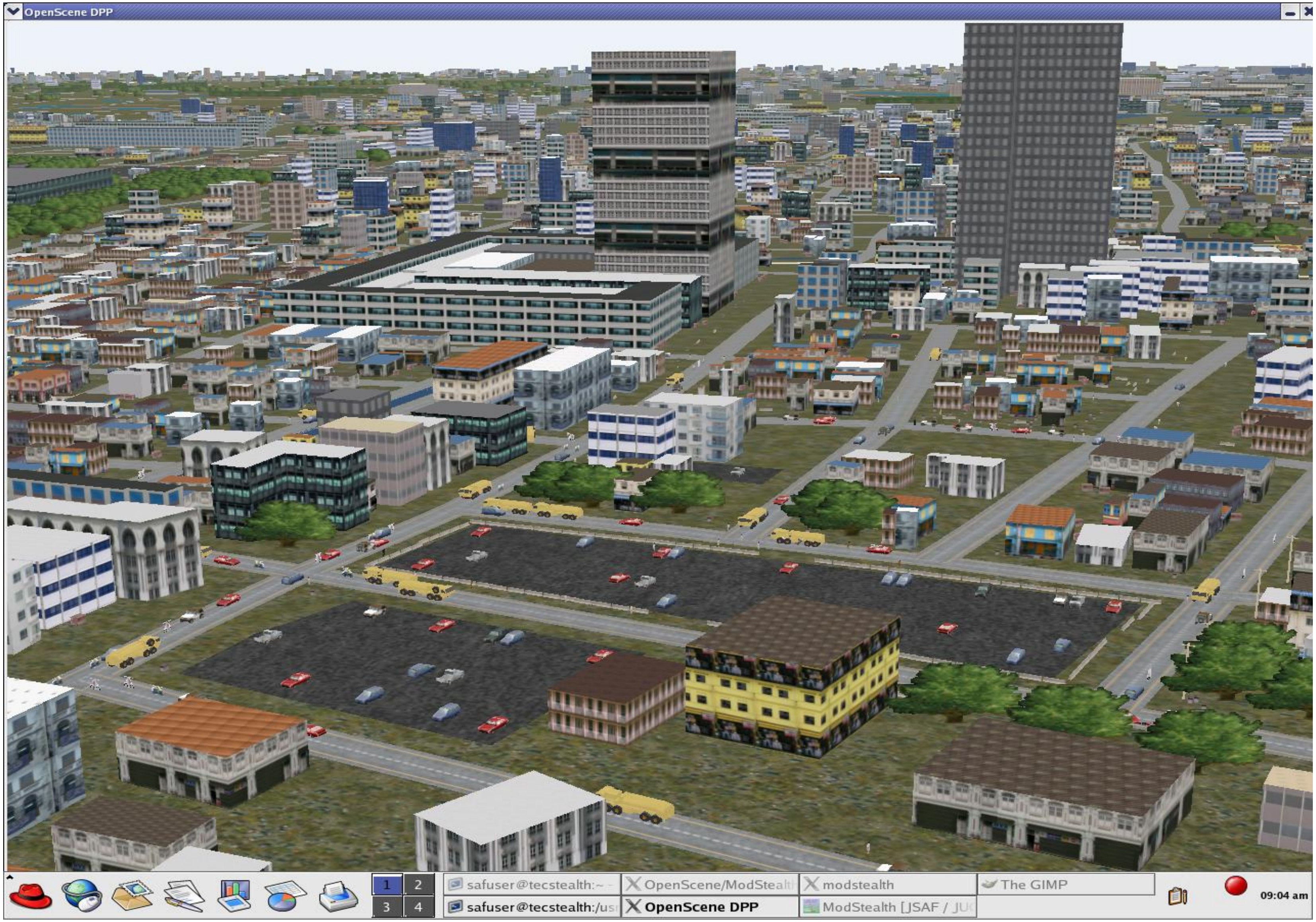
“Real World” Command & Control

- **Example: Advanced Field Artillery Tactical Data System (AFATDS)**
  - Processes fire mission and related information to coordinate/optimize the use of all fire support assets
  - Includes mortars, field artillery, cannon, missile, attack helicopters, air support, and naval gunfire

C4I Connectivity



Urban Environment – 3D Viewers



Synthetic Natural Environment

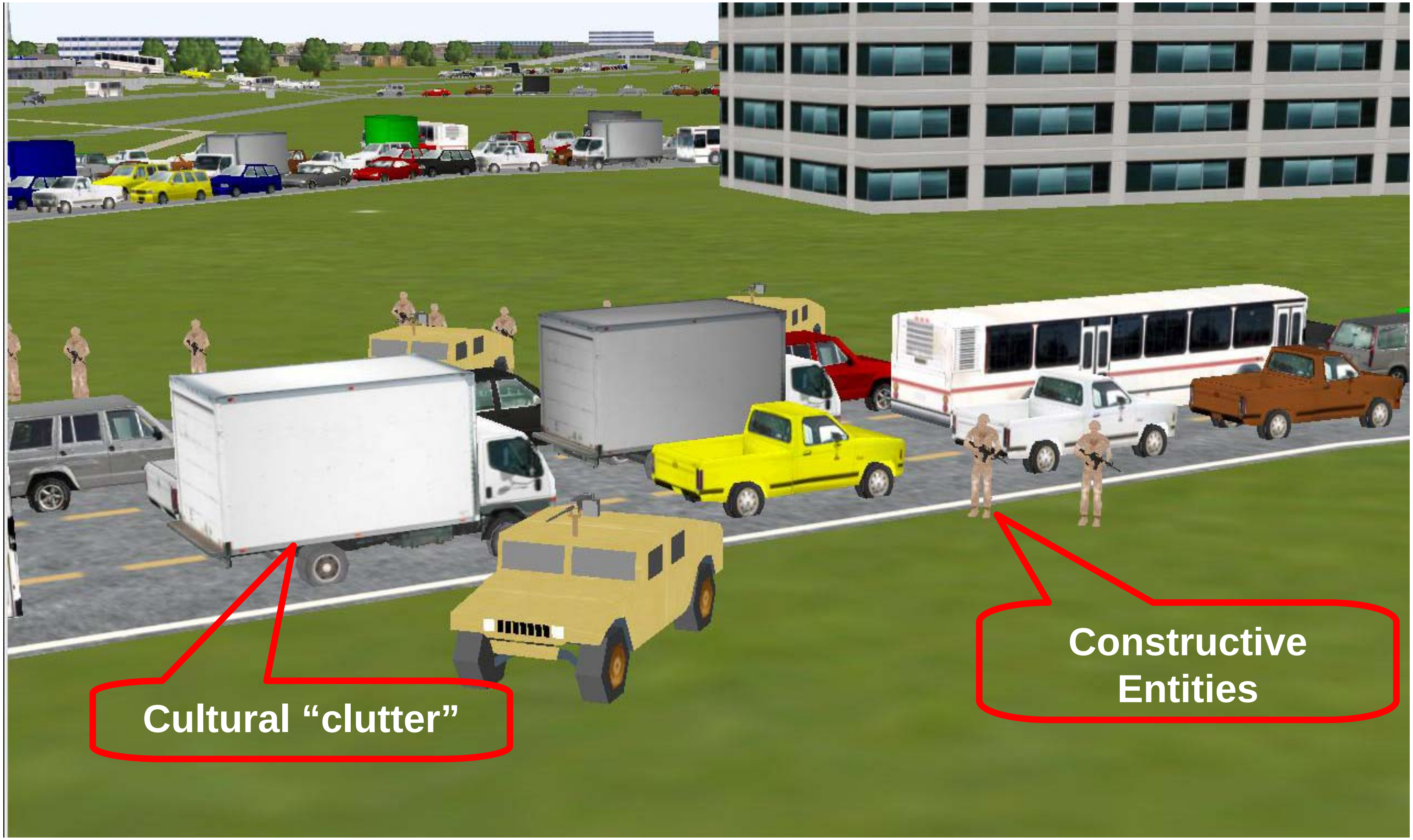
Cloud Cover, Sun Angle, Night & Day

Obscurants: Snow, Rain, Dust

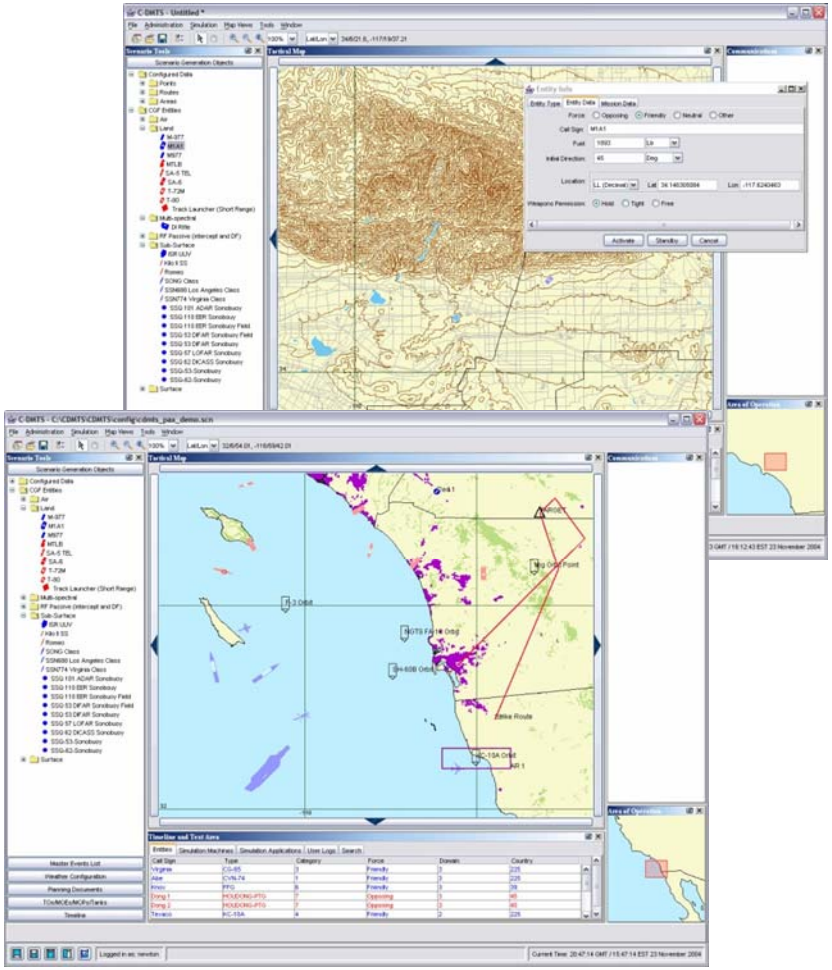
Weapon fly outs, contrails

Dynamic changes: Debris, Fire, Smoke

Urban Environment & Culture

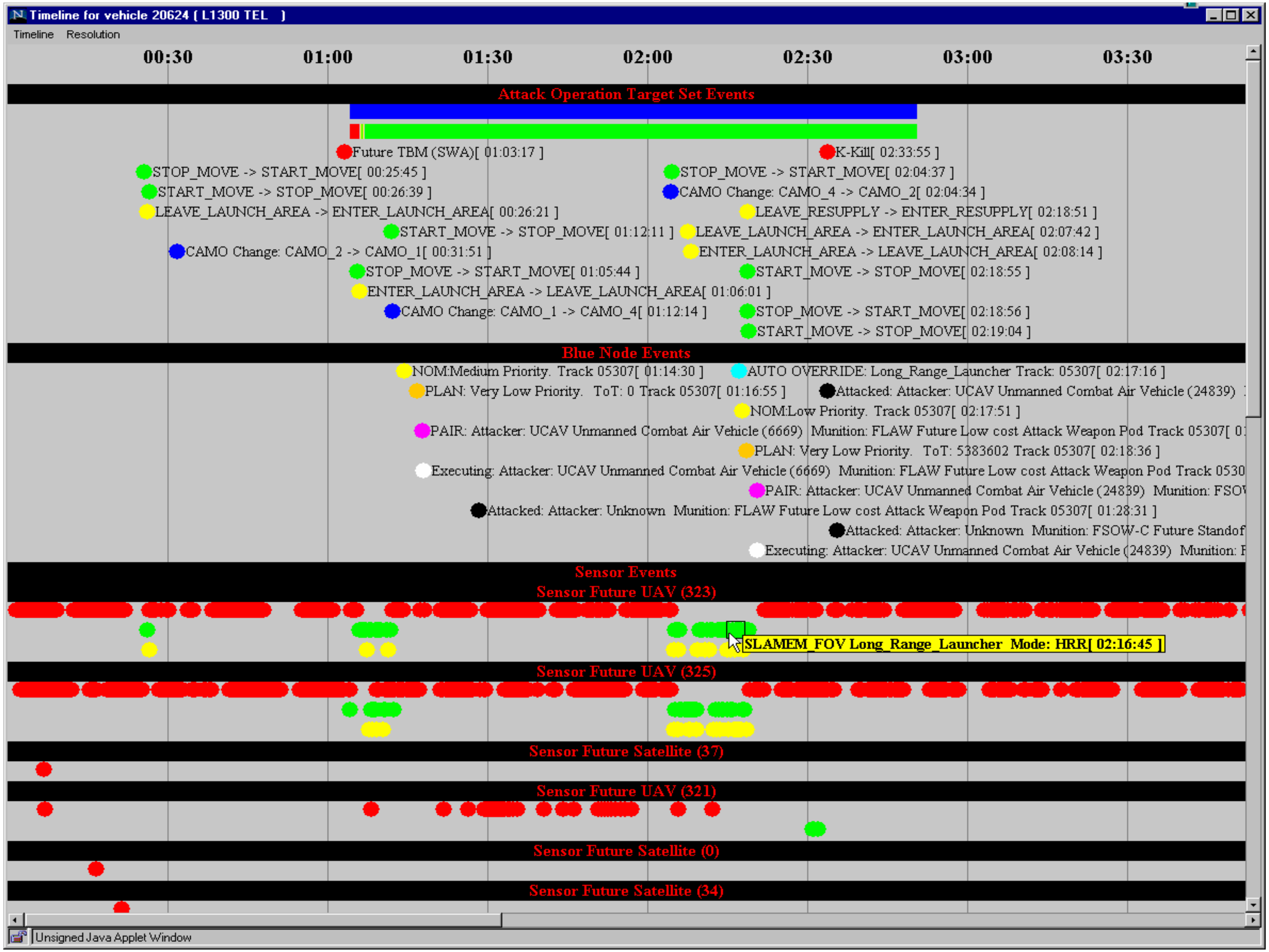


Testing Control Station



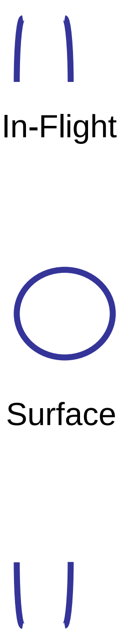
- For LVC environments
  - Planning
  - V/C scenario generation
  - V/C scenario execution/exercise control
  - After Action Review/Results
  - Test environment control
- Framework is configurable for specific testing environments.
- Support for distributed and collaborative operations.

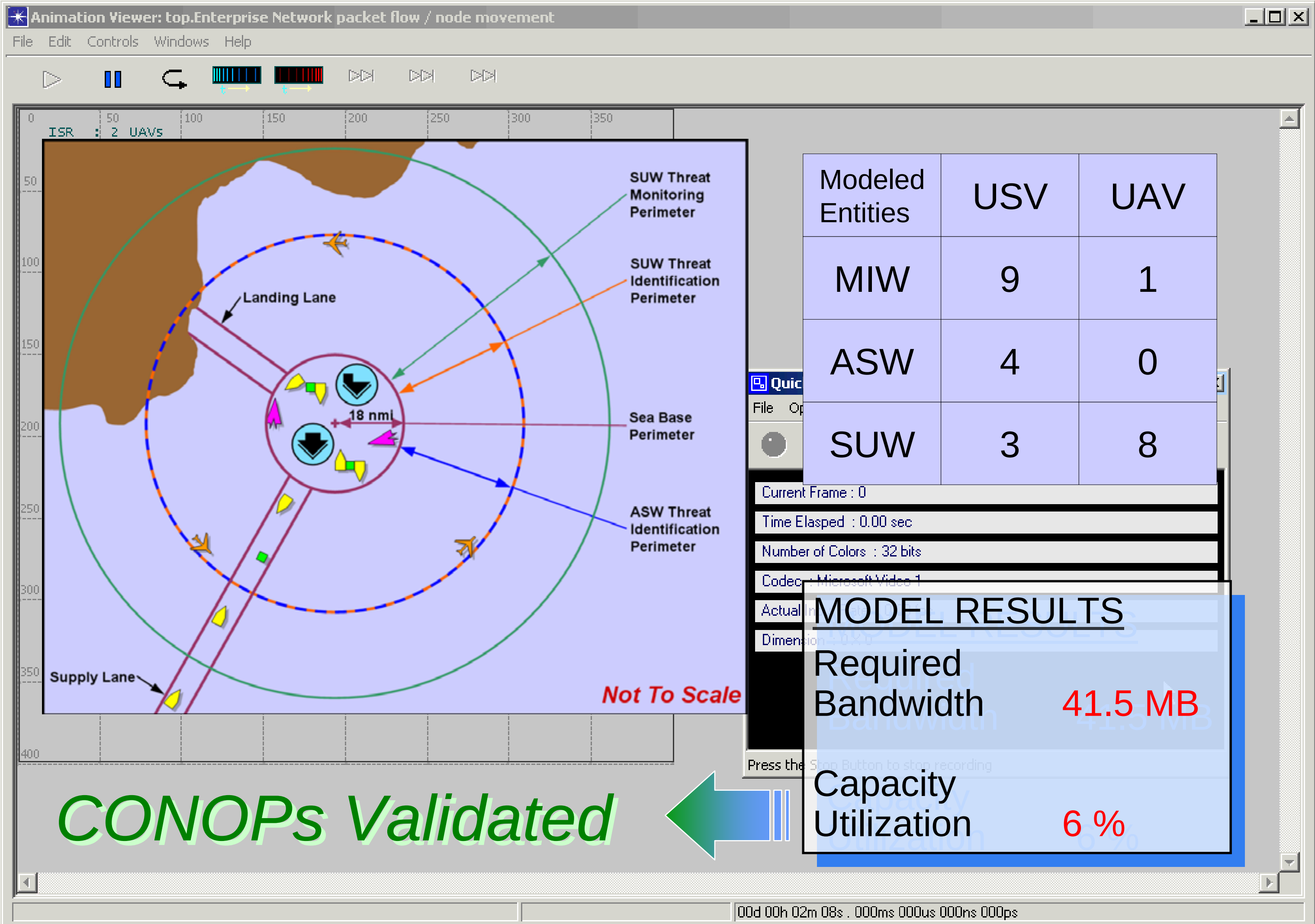
After Action Review (Test Data)



Contents

CONOPs Simulation



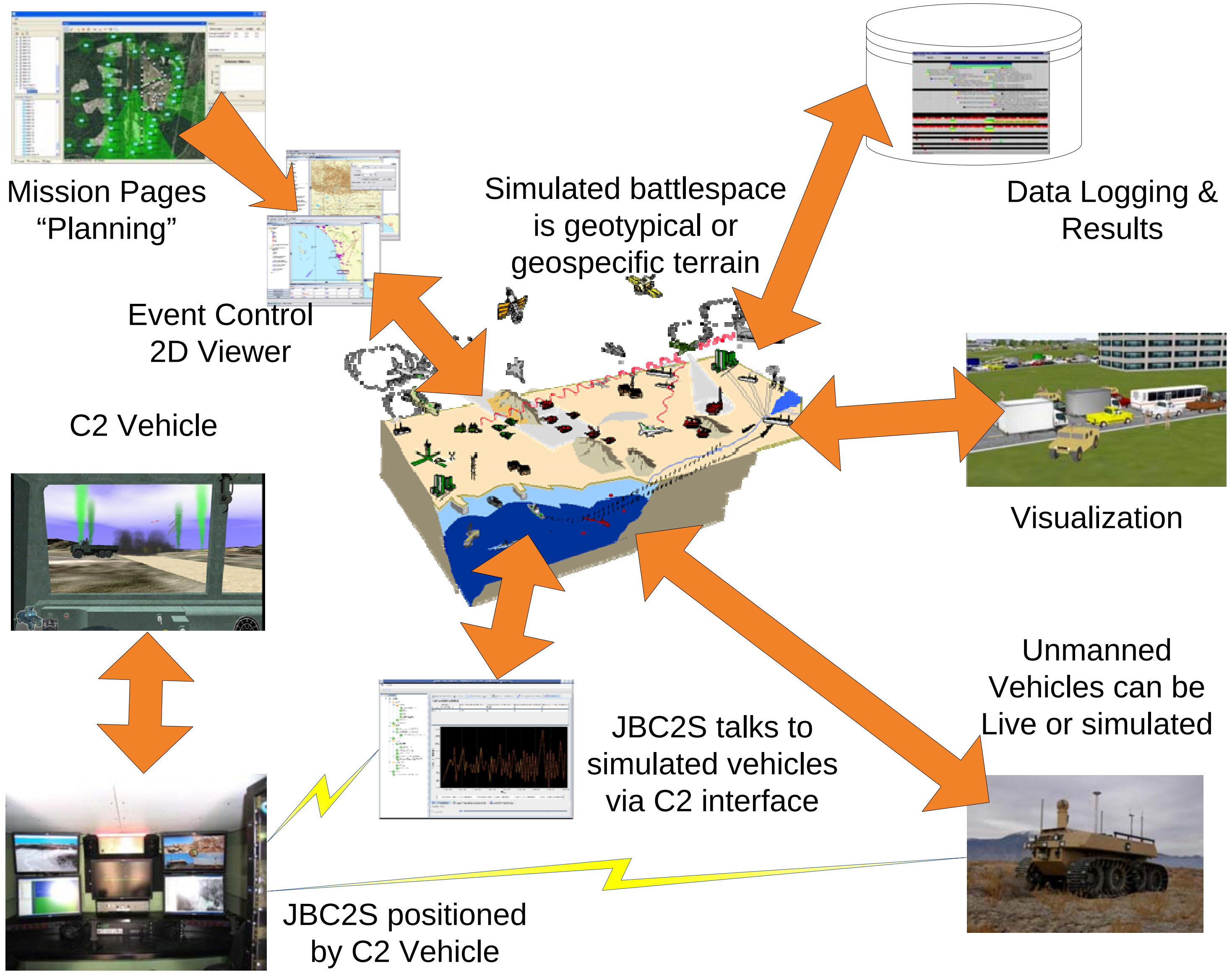


Modeled Entities	USV	UAV
MIW	9	1
ASW	4	0
SUW	3	8

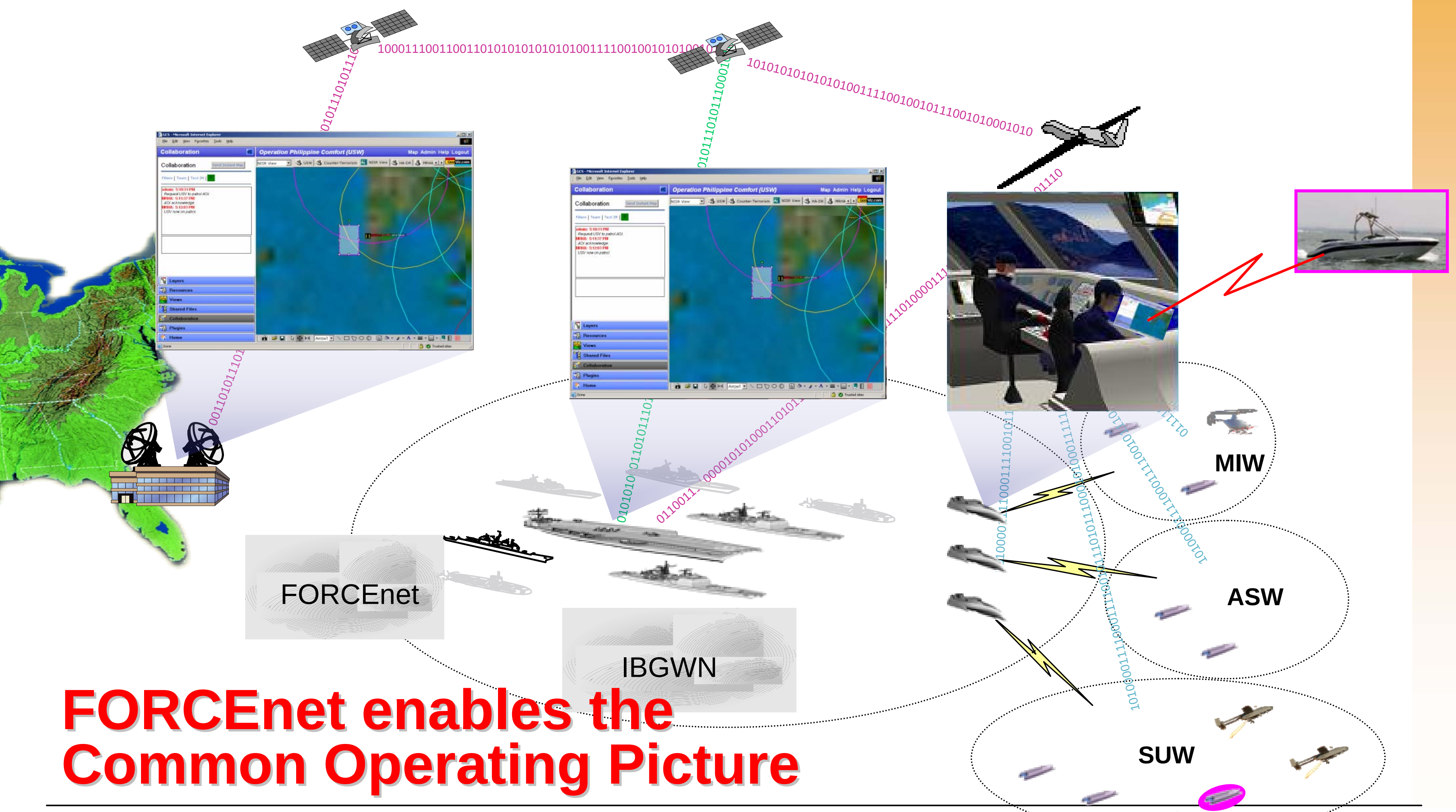
MODEL RESULTS

Required Bandwidth	41.5 MB
Capacity Utilization	6 %

The Exploration & Test Environment



UV SENTRY OPERATIONAL CONCEPT



FORCEnet enables the Common Operating Picture

referentia

Mahalo!

Questions?

gkollmorgen@referentia.com

(757) 620-1777 cell

Capability Test Methodology (CTM) Measures Framework

February 27, 2008

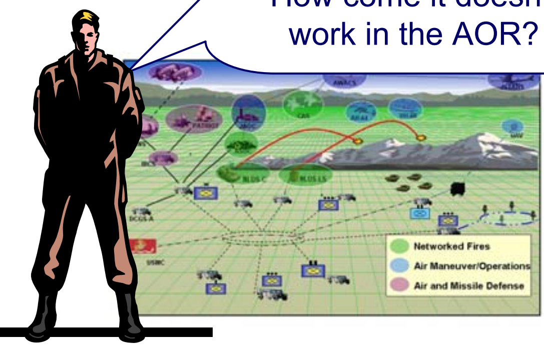
Mr. Max Lorenzo
Technical Director
757.638.6079
max.lorenzo@jte.osd.mil

Overview

- TiJE
- JTEM Overview
- Why Measures Framework ?
- CJI Construct
- CEM
- Measure Framework
  - Examples
- Way Ahead

Why Test in a Joint Environment?

Hey, this stuff passed its interoperability certs! How come it doesn't work in the AOR?



Single Service Operational Test in a Realistic Environment

"OT&E shall determine the operational effectiveness and suitability of a system under realistic operational conditions, including combat."

DoDI 5000.2, E.7
[May 2003]

ENABLING THE JOINT FORCE

Interoperability Test/Certification

". . . any resultant materiel solution will be verified through testing in the expected joint operational environment to demonstrate joint interoperability . . ."

CJCSI 3170.01F, B.3
[May 2007]

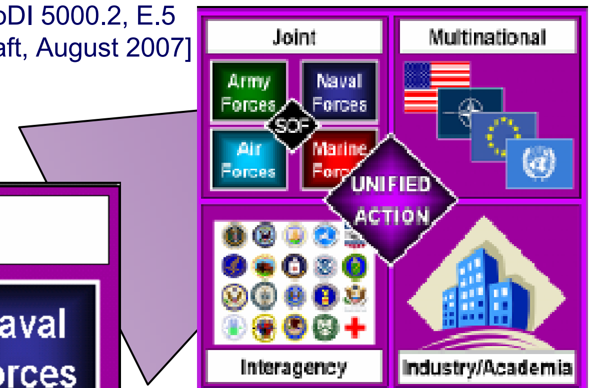
It is a requirement . . .

Test in a Joint Environment across the Acquisition Life Cycle

"Systems that provide capabilities for joint missions shall be tested in the expected joint operational environment."

DoDI 5000.2, E.5
[Draft, August 2007]

JOINT CAPABLE FORCES



Interdependent

Joint

Army Forces | Naval Forces | SOF | Air Forces | Marine Forces

Integrated

Army Forces | Naval Forces | Air Forces | Marine Forces

Coordinated

Army Forces | Naval Forces | Air Forces | Marine Forces

Deconflicted

The warfighter demands it!

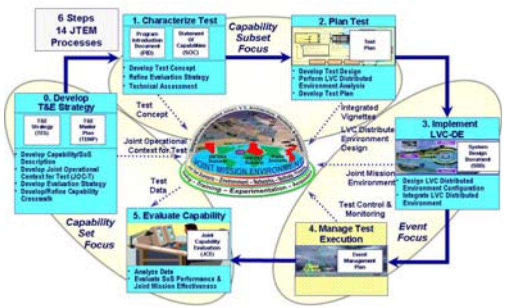
It is the right thing to do . . .

- Early discovery of problems, reduced rework costs
- Improved test data for milestone decision authorities
- Improved system characterization and limitations for Service and combatant commander planning
- Field proven joint capabilities to the combatant commander

Test like we fight

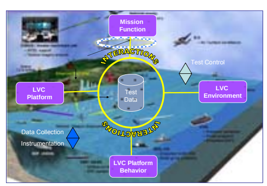
jtem@jte.osd.mil

Testing in a Joint Environment (TiJE) Methods and Processes Approach

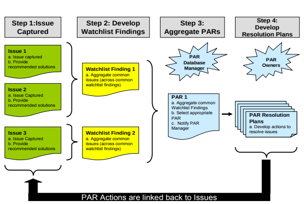


Capability Test Methodology (CTM)

Capability Evaluation Metamodel (CEM)



Joint Mission Environment Foundation Model (JFM)



Process Anomaly Reports (PAR)

- Best practices
- Consistent approach to joint mission environment (JME)
- Consistent joint capability assessments and evaluations
- Application across the acquisition life cycle

jtem@jte.osd.mil

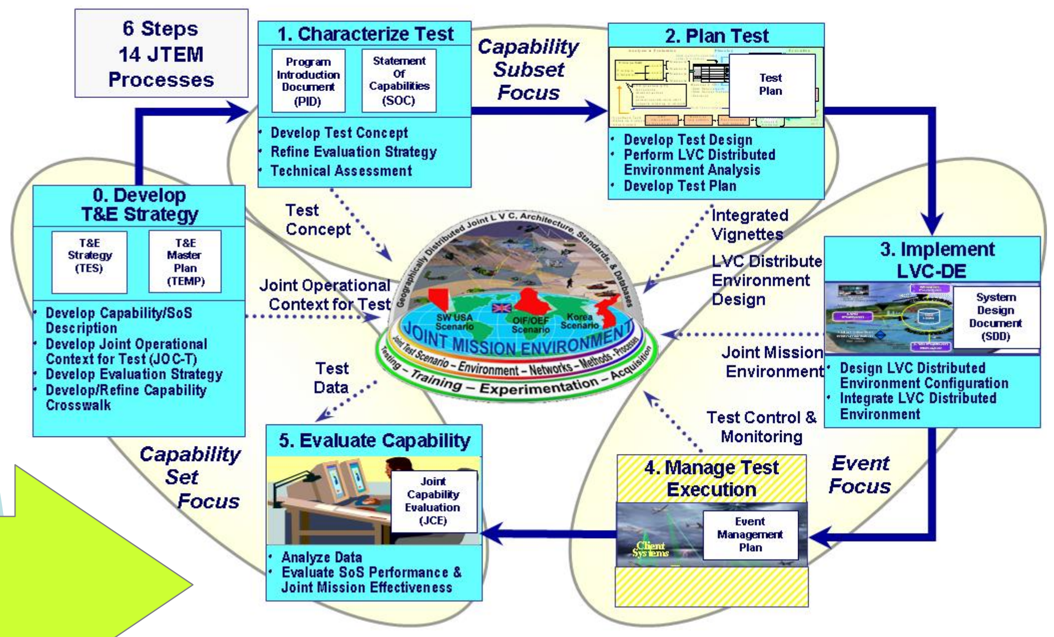
Why Measures Framework?

- For consistent answers on SoS, need standard methodologies across:
  - Services
  - Domains
- Need standard instrumentation
- Need joint tasks measured by test organizations
- Need measures rooted in JCIDS, AA, etc.

Relationship between CEM and CTM

Capability Test Methodology (CTM) Lexicon

provides underlying conceptual definitions



Capability Evaluation Metamodel (CEM)

provides underlying business rule relationships

LVC-DE – Live, Virtual, Constructive Distributed Environment

Capability Evaluation Metamodel (CEM)

- JTEM is designing a Capability Evaluation Metamodel (CEM)
  - Metamodel definition
    - An explicit model of the constructs and rules needed to build specific models within a domain of interest
    - A meta-model can be viewed from three different perspectives:
      - as a set of building blocks and rules used to build models
      - as a model of a domain of interest, and
      - as an instance of another model
  - CEM purpose
    - Provide an underlying structure for CTM evaluation methods and processes (for example, CTM evaluation-related template content and relationships)
    - Provide business rule relationships for the CTM evaluation thread

CEM Key Relationships

Joint Mission Desired Effects

- Disrupt Red Combat forces moving in battle area.
- Attrite Red Combat forces in the battle area.
- Support Blue maneuver in the battle area.
- Protect Blue forces in the battle area.

Mission MOEs

Analytic Agenda → Provide COCOM

Joint Tasks

SN 1, "Conduct Strategic Deployment and Redeployment"

OP 1, "Conduct Operational Movement and Maneuver"

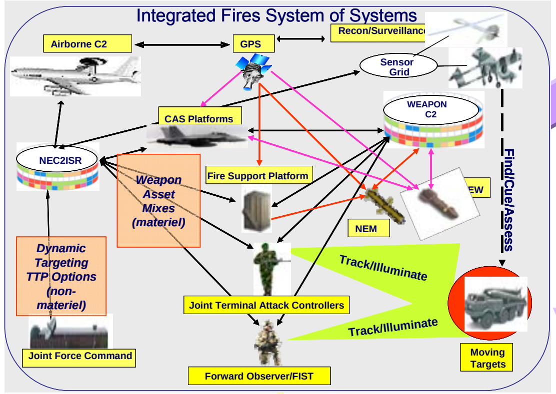
TA 1, "Deploy/Conduct Maneuver"

Task MOPs

Achieve

UJTL → List

Joint Capability

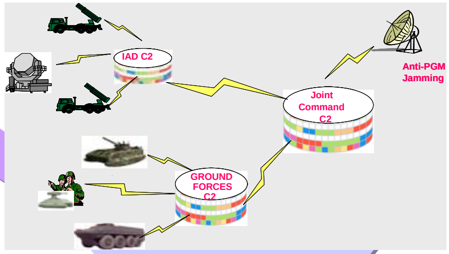


Perform

JCIDS Acquisition → Address Capability Gaps

JCAs → List

System of Systems



Describe

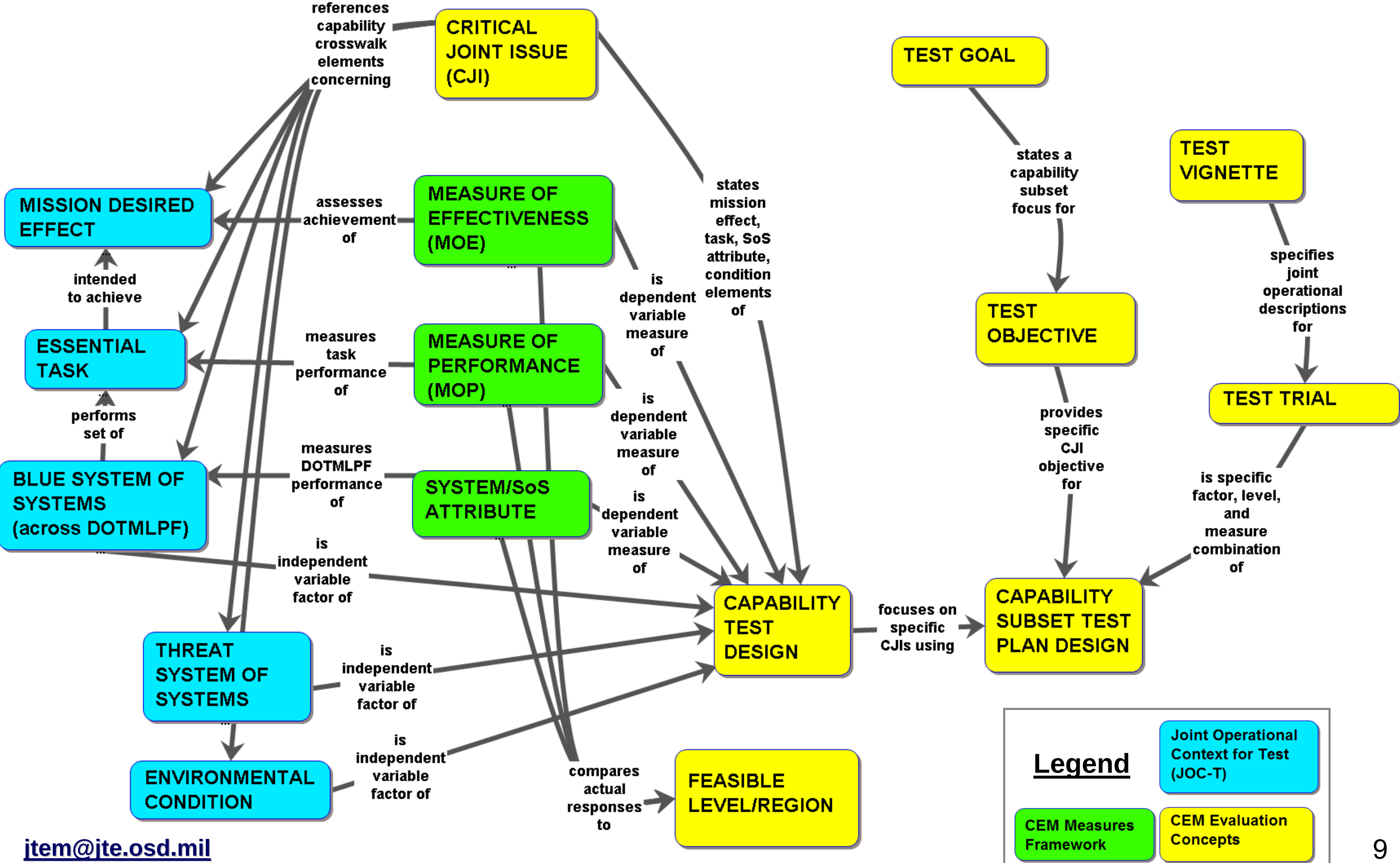
SoS Attributes

CTM establishes the M&P to test SoS ability to provide the means and ways to perform a set of tasks in order to achieve the set of desired effects that lead to mission success

CEM – Capability Evaluation Metamodel
JCIDS – Joint Capabilities Integration and Development System
MOP – Measure of Performance
CTM – Capability Test Methodology
M&P – Methods and Processes
SoS – System of Systems
JCA – Joint Capability Area
MOE – Measure of Effectiveness
UJTL – Universal Joint Task List

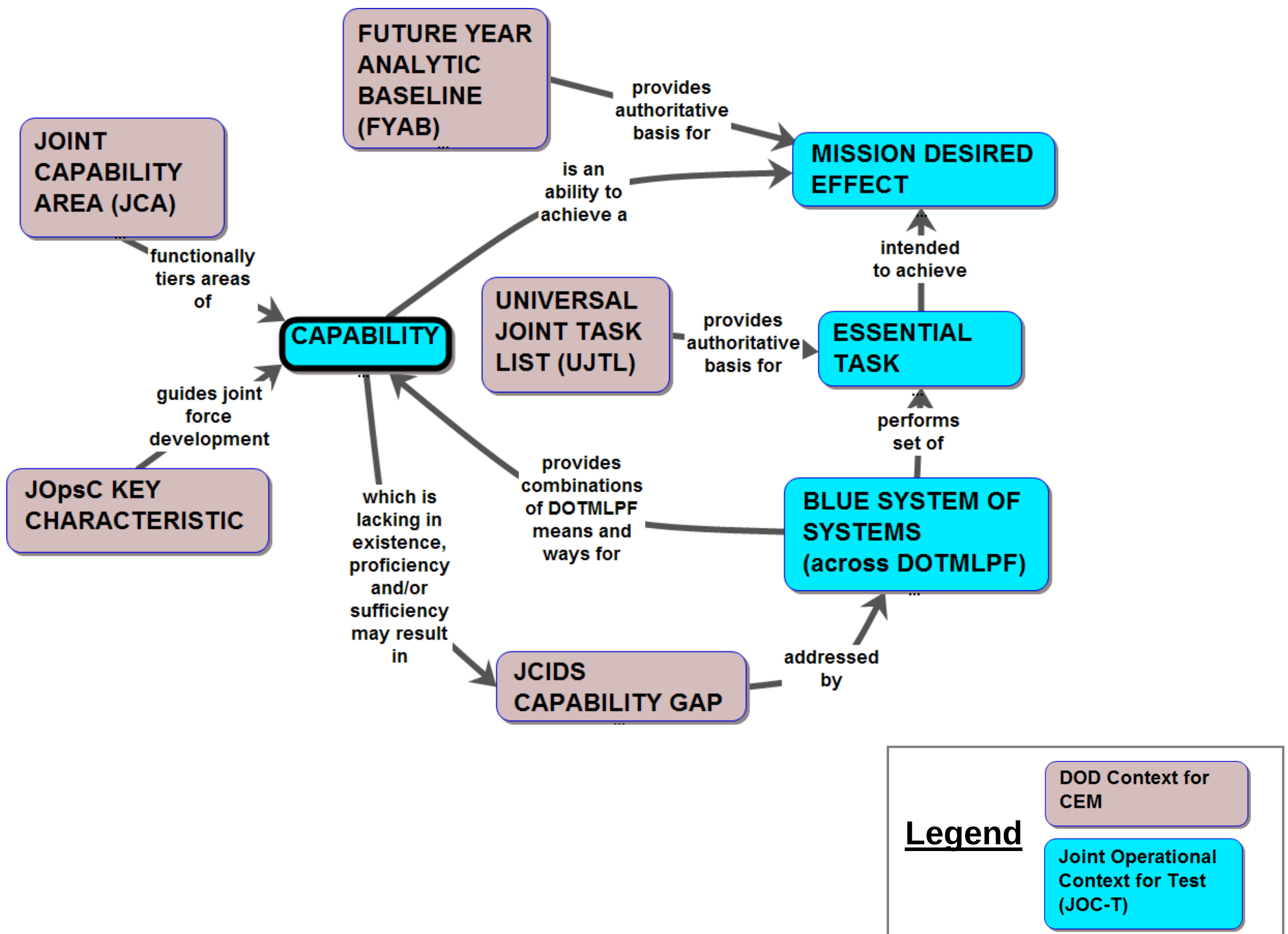
jtem@jte.osd.mil

Capability Evaluation Metamodel (CEM): Test Plan Design

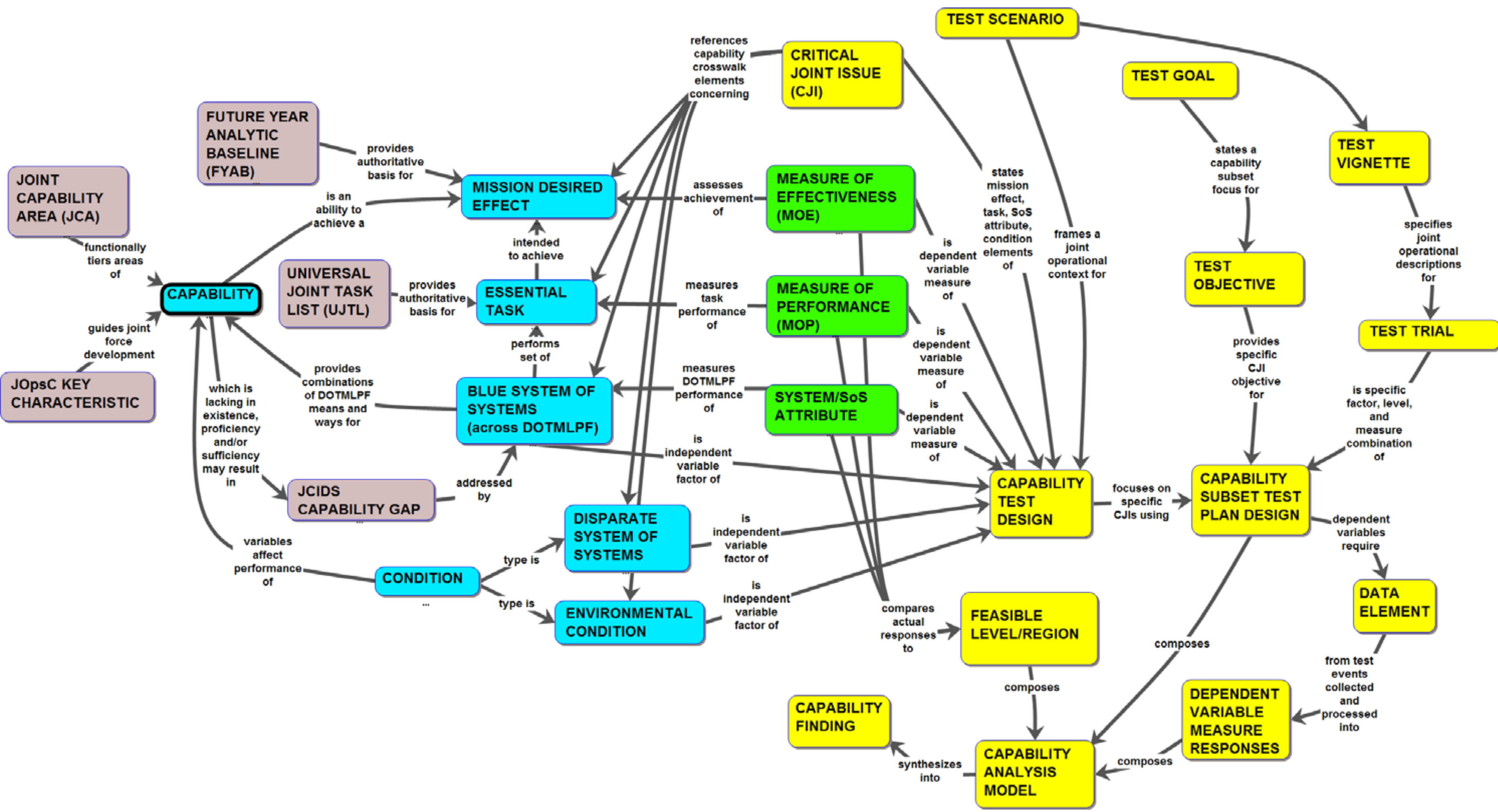


jtem@jte.osd.mil

Capability Evaluation Metamodel (CEM): DOD Context for CEM JOC-T



Capability Evaluation Metamodel (CEM): Global View



Evaluation Strategy Overview

- **Critical Joint Issue (CJI) Checklist**
  - Is the CJI:
    - Used to assess performance as it pertains to capabilities supporting joint missions?
    - Structured as a question addressing joint capability areas described in Joint Capability Documentation?
    - Addressing the system of systems ability to perform joint operational tasks and/or the system of systems, system, or service attribute performance?
  - Does the CJI phrasing include SoS contribution to achieving the desired mission end state outcomes in terms of mission desired effects?
  - CJIs should be of primary importance to the decision authority in reaching a decision to allow the system of systems to advance into the next phase of development.

- **CJI Example Template:**

  Can the Capability perform <u>Task X</u> by <u>SoS Configuration Y</u> under <u>Condition A</u> to achieve <u>Mission Desired Effect Z</u>?

Measures Framework

Service-acquired capabilities

that perform joint tasks

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

to accomplish a joint mission

Critical joint issues assess system and task performance pertaining to capabilities which support joint missions.

Measures Framework

COIs & system/SoS attributes (KPP, CTPs)

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

- Systems measure critical technical parameters (CTP) (attributes, that when achieved, allow attainment of desired operational capabilities) to resolve critical operational issues (COI) regarding task accomplishment

The program manager/OTA need to know if the SUT can accomplish the required task in the Joint Operational Context for Test.

Measures Framework

System/System of Systems ↔ act & interact ↔ System/System of Systems → to contribute to → **Joint Task(s) Accomplishment (TMOP)**

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

- Systems are combined to accomplish Universal Joint Tasks which are measured at the System of Systems level (Services acting in concert to achieve a task)

Joint tasks are measured by a Task Measure of Performance derived from UJTL references (after Joint Capability Area analysis).

Measures Framework

System/System of Systems	act & interact ↔	System/System of Systems	to contribute to →	**Joint Task(s) Accomplishment (TMOP)**

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

Mission Desired Effect (MMOE)

- One or more tasks contribute to desired effect(s)/end state

Mission Measure of Effectiveness (MMOE) measures desired end state(s) (desired effects) that result from task performance.

Integrated Fires Capability Operational Concept Graphic (OV-1)

Mission Statement

Blue Forces conduct Joint Forcible Entry Operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the Joint Operations Area (JOA)

End State

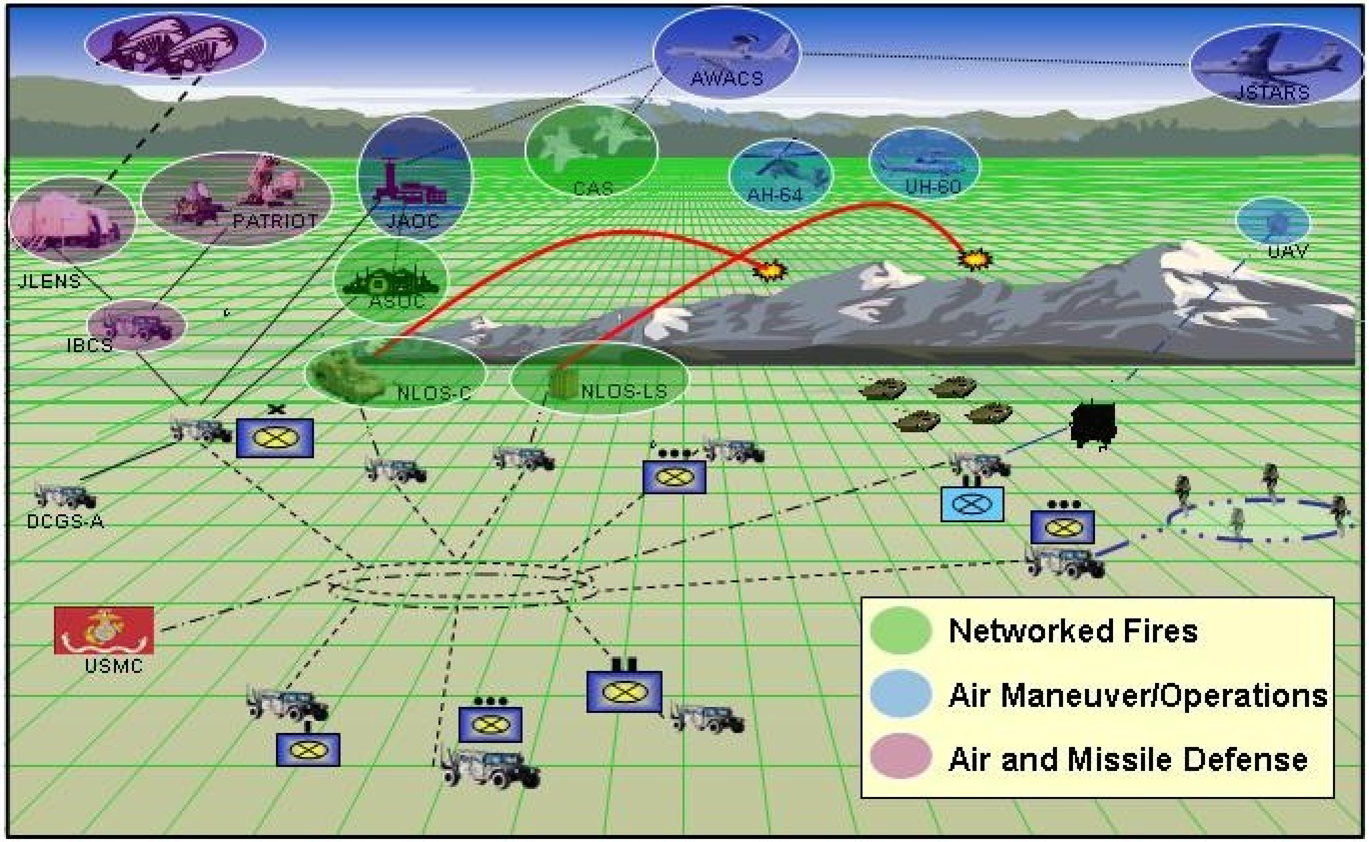
- Expand lodgment and control key infrastructure to facilitate rapid force build-up
- Preserve key infrastructure and prevent environmental contamination
- Secure LOCs to facilitate flow of forces needed to conduct regime change operations

Desired Effects

- Destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)
- Blue unhindered in maneuver within the JOA
- Blue force survivability in the JOA

to help achieve

Integrated Fires System of Systems



Tasks

Networked Fires

Detect → Fuse → Allocate → Engage → Assess

Air Maneuver/Ops

Monitor → Coordinate → Redirect

Air & Missile Defense

Detect → Fuse → Allocate → Engage → Assess

Provides the ability to perform

Mission MOE: Threat Systems Combat Ineffectiveness

(Percentage of threat systems rendered ineffective [killed, damaged, dislocated] compared to Blue desired value)

Mission Statement

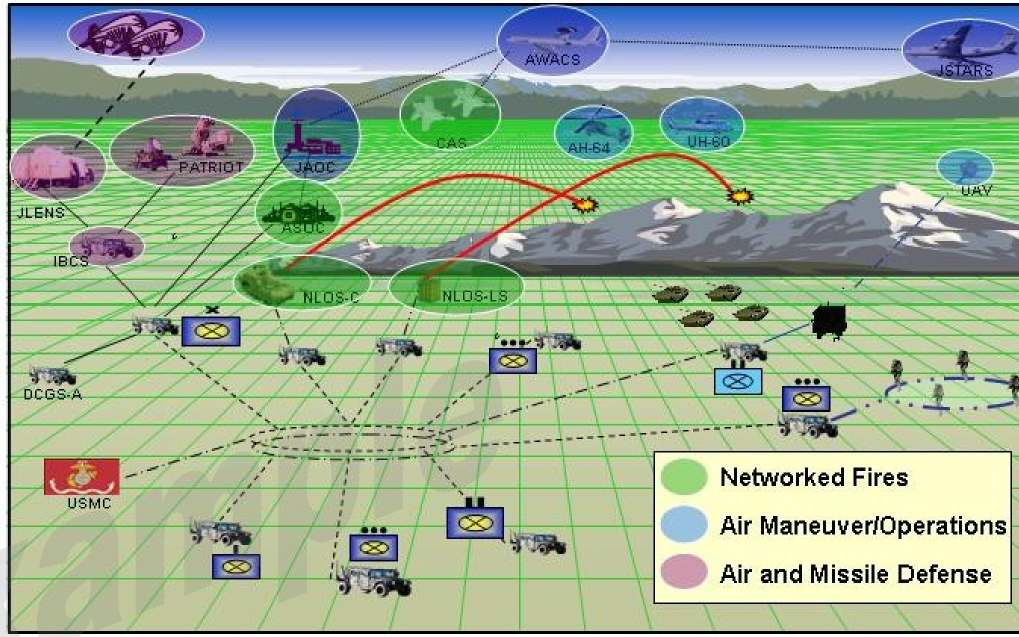
Blue forces conduct joint forcible entry operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the joint operations area (JOA)

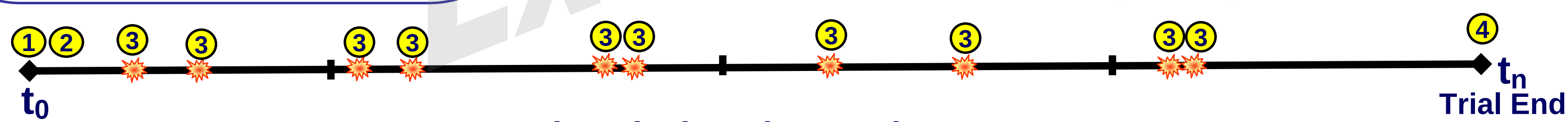
End State

Expand lodgment and control key infrastructure to facilitate rapid force build-up

Desired Mission Effect

Destroyed or neutralized threat forces (in zone, moving into zone, indirect fires, ADA)





Joint Mission Time Horizon

Sequence of Events

1. Mission start at time t_0. Threat forces in JOA or moving into JOA. Blue forces conducting joint forcible entry operations.
2. Blue forces employ Networked Fires task thread to prosecute threat targets.
3. Threat systems killed, damaged, or dislocated.
4. Mission complete at time t_n

Mission MOE: Threat Systems Combat Ineffectiveness

(Percentage of threat systems rendered ineffective [killed, damaged, dislocated] compared to Blue desired value)

Data Elements

1. Blue Desired Fraction of Threat Systems in JOA Combat Ineffective at Mission End State (threshold value)
2. Cumulative count Threat Systems in zone over time (System Type, Time, Location)
3. Cumulative count Threat Systems Killed (System Type, Time, Location)
3. Cumulative count Threat Systems Combat Damaged (System Type, Damage Type, Time, Location)
3. Cumulative count Threat Systems Dislocated (System Type, Dislocation Type, Time, Location)

Key Terms

1. **Threat Mounted Systems**: Those threat mounted systems that either are in the JOA at trial start or enter the JOA during the trial period. System does not have to still be in JOA at trial end to be counted. A system will also not be counted more than once (if enters JOA more than once). (**System Type**: identifying type; **Time**: Time at which entered JOA; **Location**: Positioning data at time which entered the JOA. If in JOA at trial start, then position at trial start time)

2. **Threat Mounted System kill**: Those threat systems that can no longer move, shoot, and sense. System no longer possesses a capability. Assumes cannot be fixed and remains a kill until trial end. (**System Type**: identifying type; **Time**: Time at which killed; **Location**: Positioning data at time which killed)

3. **Threat Mounted System damaged**: Those threat systems that can no longer shoot but are not killed. System is combat ineffective but still retains some capability to move or sense. (**System Type**: identifying type; **Damage type**: S – unable to shoot, SM – unable to shoot and move, SS – unable to shoot and sense; **Time**: Time at which entered damaged state. Must remain in damaged state to trial end to be counted. If later attacked and killed, then counted as a kill. If moves out of JOA or goes into hiding, still considered damaged and not dislocate; **Location**: Positioning data at time which entered damaged state)

4. **Threat Mounted System dislocated**: Those threat systems that are not combat effective in the JOA at trial end. System either leaves the JOA and remains outside the JOA until trail end, or system is in the JOA and hiding at trial end to avoid attack. Hiding assumes it is unable to move, shoot, or sense. A system is only counted as dislocated if in that state at trial end. (**System Type**: identifying type; **Dislocation type**: departed, denied, hidden; **Time**: Time at which entered dislocated state. Reset if system goes out of dislocated state before trial end; **Location**: Positioning data at time which entered dislocated state. Assumes does not move if remains in dislocated state until trial end)

Calculation

$$\frac{\left(\dfrac{\sum \text{Threat Systems Combat Ineffective (killed} \vee \text{damaged} \vee \text{dislocated) in JOA at trial end}}{\sum \text{Threat Systems in/newly entered JOA by trial end}}\right)}{\left(\text{Blue Desired Fraction of Threat Systems Combat Ineffective in JOA at Mission End State}\right)}$$

Success Criteria

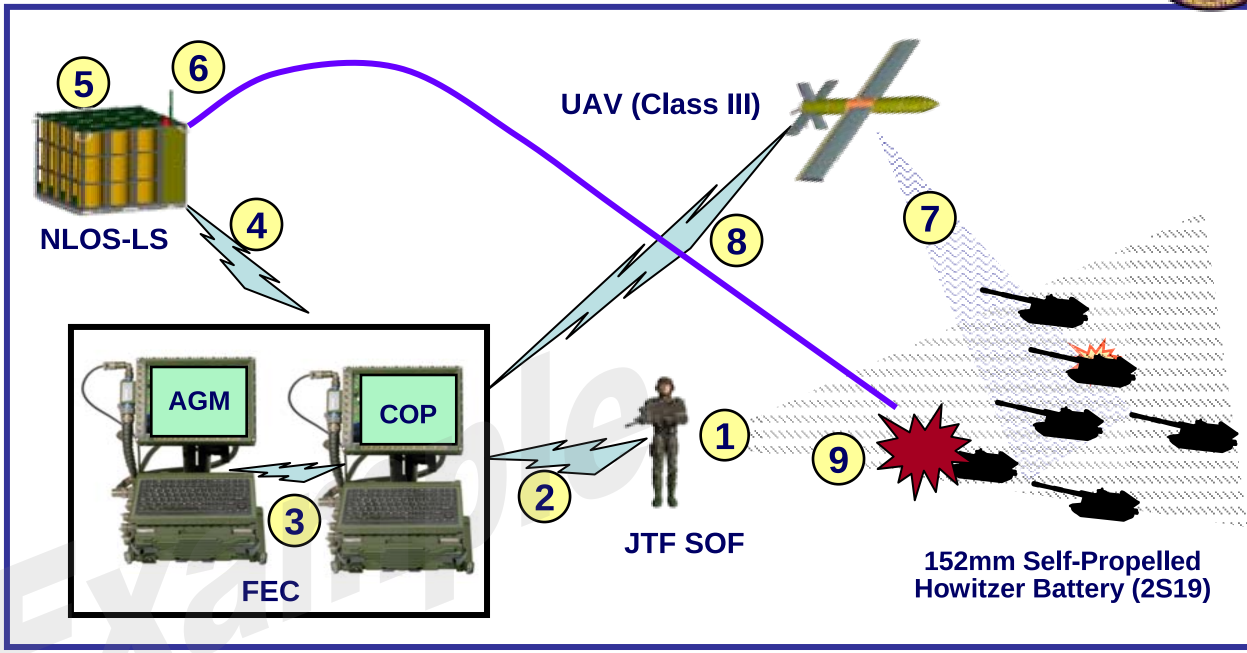
MMOE ≥ 1.0

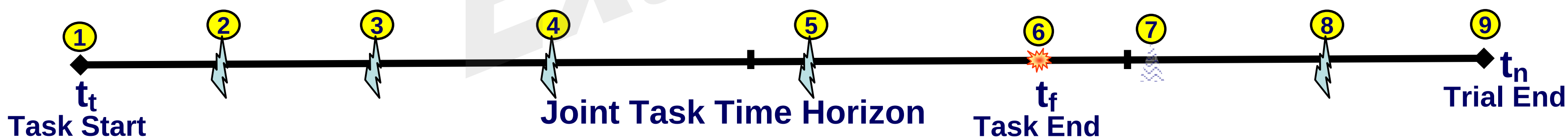
Task MOP: Percentage targets attacked IAW requests for fires
(Number of targets attacked compared to total number of requests for fires)

Mission Statement
Blue Forces conduct Joint Forcible Entry Operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the Joint Operations Area (JOA)

Joint Task
***TA 3.2.1 Conduct Joint Fires*:**
Employ Fires that support land, maritime, amphibious, and special operation forces to engage enemy forces, combat formations, and facilities in pursuit of tactical and operational objectives.

MOP (M1)
Percentage targets attacked IAW requests for fires





Sequence of Events
1. JTF SOF soldier detects 2S19 Battery at start time t_d
2. JTF SOF soldier reports 2S19 target information to the FEC to populate the COP.
3. Decision is made to engage the 2S19s with PAM. Request for fires is made.
4. NLOS-LS receives fire mission
5. NLOS-LS processes the target acquisition information and is prepared to fire PAM.
6. NLOS-LS fires PAM at time t_f
7. Class III UAV detects effects.
8. BDA report is sent to FEC for COP update and potential re-targeting/re-attack.
9. Ground truth of target effects.

Task MOP: Percentage targets attacked IAW requests for fires

(Number of targets attacked compared to total number of requests for fires)

Data Elements

1. **Blue Target Engagement Objective Value**
3. **Number of requests for fire**
6. **Number threat systems attacked from requests for fire**

Key Terms

1. **Threat Systems (TS_d) detected in JOA** : Those threat systems **(TS_d)** that are detected in the JOA and a request for fires is executed. (**System Type**: identifying type; **Detection time**: Time at which TS was first detected (t_{d}.), Request for Fires time: Time at which request for fires on TS was executed (t_{r}.)

6. **Threat Systems (TS_k) targeted in JOA** : Those threat systems **(TS_k)** that are targeted and attacked in the JOA during the trial period. (**System Type**: identifying type; **Fires time**: Time at which TMP was fired on (t_{f}.)

Calculation

$$TMOP = \frac{\dfrac{\sum \text{Threat Systems Attacked from Requests for Fire}}{\sum \text{Requests for Fire}}}{\text{BlueTargetEngagementObjectiveValue}}$$

Success Criteria

TMOP ≥ 1.0

SoS Attribute: Rapid Fires Engagement

(Average time to engage targets from networked fires)

Mission Statement

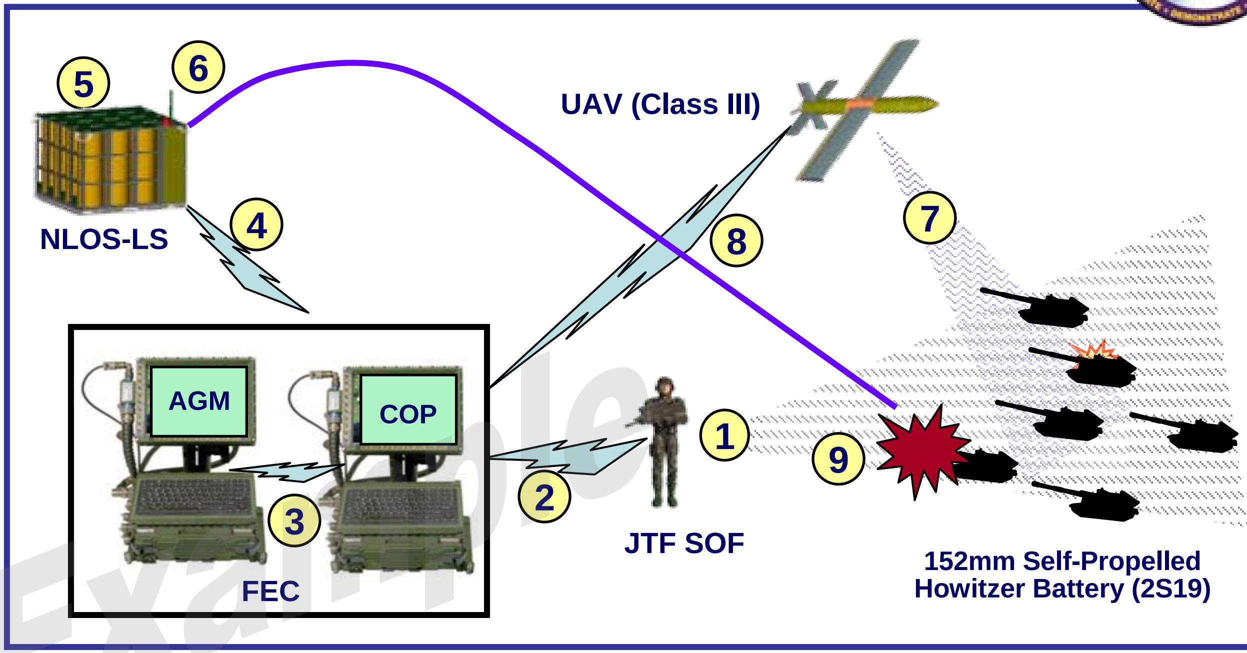
Blue Forces conduct joint forcible entry operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the joint operations area (JOA)

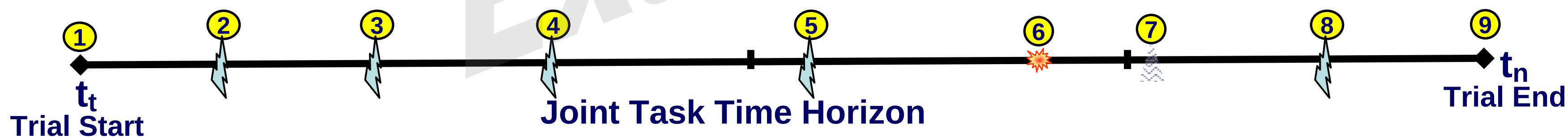
System of Systems (SoS)

Networked Fires

SoS Performance Areas

Doctrine
Organization
Training
Materiel
Leadership
Personnel





Sequence of Events

1. JTF SOF soldier detects 2S19 Battery at start time t_d
2. JTF SOF soldier reports 2S19 target information to the FEC to populate the COP.
3. Decision is made to engage the 2S19s with PAM
4. NLOS-LS receives fire mission
5. NLOS-LS processes the target acquisition information and is prepared to fire PAM.
6. NLOS-LS fires PAM at time t_f
7. Class III UAV detects effects.
8. BDA report is sent to FEC for COP update and potential re-targeting/re-attack.
9. Ground truth of target effects.

SoS Attribute: Rapid Fires Engagement

(Average time to engage targets from networked fires)

Data Elements

1. BlueDesiredEngagementTime
1. Cumulative Count Threat Systems Engaged
1. Threat System detection time (t_d)
6. Threat System fires time (t_f)

Key Terms

1. **Threat Systems (TS_d) detected in JOA**: Those threat systems **(TS_d)** that are detected in the JOA and a request for fires is executed. (**System Type**: identifying type; **Detection time**: Time at which TS was first detected ($t_{d\cdot}$), Request for Fires time: Time at which request for fires on TS was executed ($t_{r\cdot}$))

6. **Threat Systems (TS_k) targeted in JOA**: Those threat systems **(TS_k)** that are targeted and attacked in the JOA during the trial period. (**System Type**: identifying type; **Fires time**: Time at which TMP was fired on ($t_{f\cdot}$))

Calculation

$$BET = \frac{\dfrac{\sum\left(\text{ThreatSystemFiresTime } t_f \ - \ \text{ThreatSystemDetectionTime } t_d\right)}{\text{CumulativeCountThreatSystemsEngaged}}}{\text{BlueDesiredEngagementTime}} \quad \forall \ TS_k \quad \text{and Engaged}$$

Success Criteria

BET ≥ 1.0

Path Forward

- Need Analysis Framework
- Need regular tests in JCAs
- Need CONUS virtual range stood up

Colonel Eileen Bjorkman
Joint Test Director
757.638.6099
eileen.bjorkman@jte.osd.mil

Mr. Max Lorenzo
Technical Director
757.638.6079
max.lorenzo@jte.osd.mil

jtem@jte.osd.mil


X-47A
NORTHROP GRUMMAN

Test Pilot’s Role in Flight Test of Unmanned Air Vehicles

Roy Martin
Chief Test Pilot
Northrop Grumman Air Combat Systems

Abstract

With Increasing Emphasis on the Development of Unmanned Air Vehicles (UAV), the Test Pilot May Be Assigned to Perform Various Duties on the UAV Test Team. The Purpose of This Briefing Is to Highlight Some of the Tasks That May Be Assigned to a Test Pilot on a UAV Test Team. Information on Accomplishing These Tasks from Previous UAV Programs Are Presented. The Information Is Derived Primarily from the Author's Experience Performing Duties as Chase Pilot, Surrogate Aircraft Test Pilot, and Air Vehicle Operator on Various UAV Flight Test Programs.

AVO role for UAV Analogous to Test Pilot Role

- AVO Role Defined in Early Design Decisions
- Command and Control Location
- AVO Display Requirements
- Surrogate Aircraft Flight Testing
- Chase Aircraft
- Contingency Planning
- Summary / Lessons Learned

AVO Role Defined in Early UAV Design Decisions

- Fully Autonomous UAV – Range Safety Role
- Autonomous Takeoff / Landing UAV
  - AVO Cannot Manually Takeoff / Land the UAV
  - AVO Involved in Decisions Related to Taxi and Takeoff Abort, Contingency Profiles, Waveoff, Destruct
  - Limited Capability to Control Flight Path – Manual Override Airspeed / Altitude / Bank Angle
- Manual Control of Takeoff / Flight Path / Landing
  - AVO Fully Responsible for Flight Path Control Through Remote Control Inputs

Command and Control Locations

- AVO in Cockpit of Chase Aircraft
  - Communication Issues
  - Removed from Engineering Decisions
- AVO in Remote Ground Based Location
  - Same Issues as Inflight Location
- AVO Co-Located with Engineering Decisions
  - Visual Response Supplements Net Communication
  - Advantageous to Co-Locate AVO with RSO

Control Room Configuration

- AVO Visual with Test Director / Test Conductor / Engineers to Supplement Net Communication
- AVO Share Displayed Information with RSO
- Radio Communication with Ground Crew / Chase Aircraft / Tower / Range Control
- External Camera View of UAV Highly Desired
- Forward Looking Camera from UAV Critical for Landing Decisions

X-47A Control Room

NORTHROP GRUMMAN
Integrated Systems

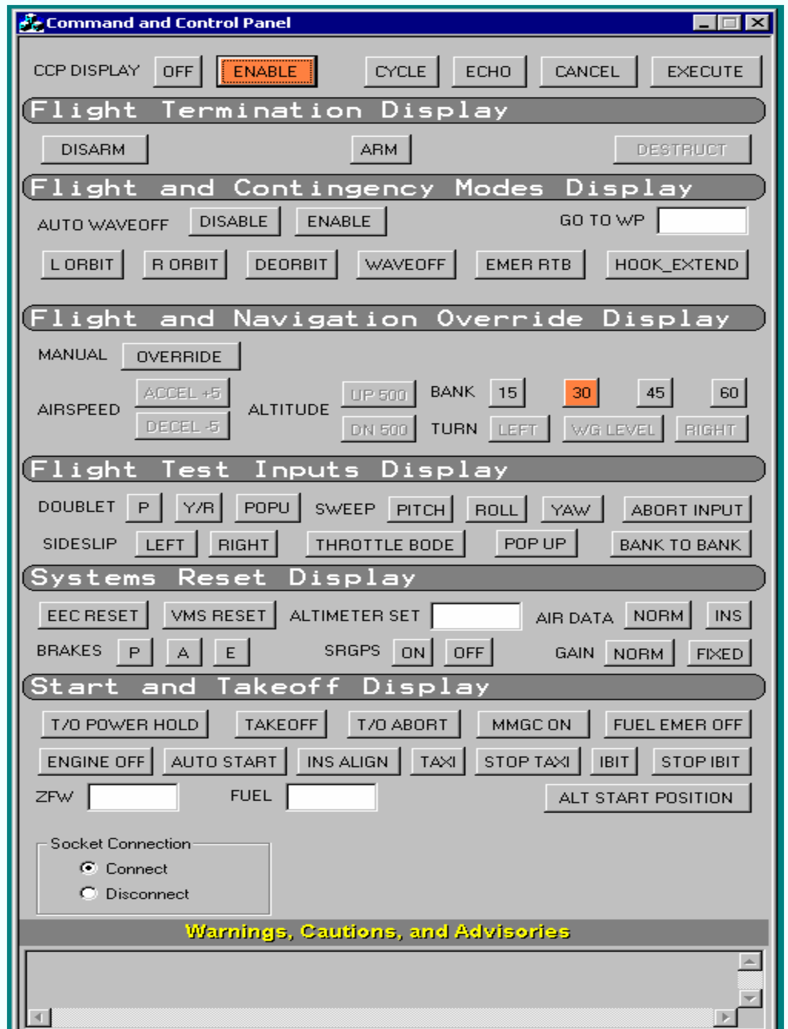
X-47A AVO Station

AVO Command Display Requirements

- AVO Command and Control Panel
  - AVO Selects and Executes Commands to Be Uplinked to UAV Using Hardwired Panel or Computer Display (More Flexible / Transportable)
  - Need Feedback That Uplinked Command Was Sent (Use of Color Change on Display Is Effective)
  - “Echo” Command Is Useful
- Use of “Mouse” to Select Commands on Display
- Limited Keyboard Entry (i.e., Altimeter Setting, ZFW, Go to WP, Mission Plan Number, etc.)

NORTHROP GRUMMAN
Integrated Systems

Sample Command Display

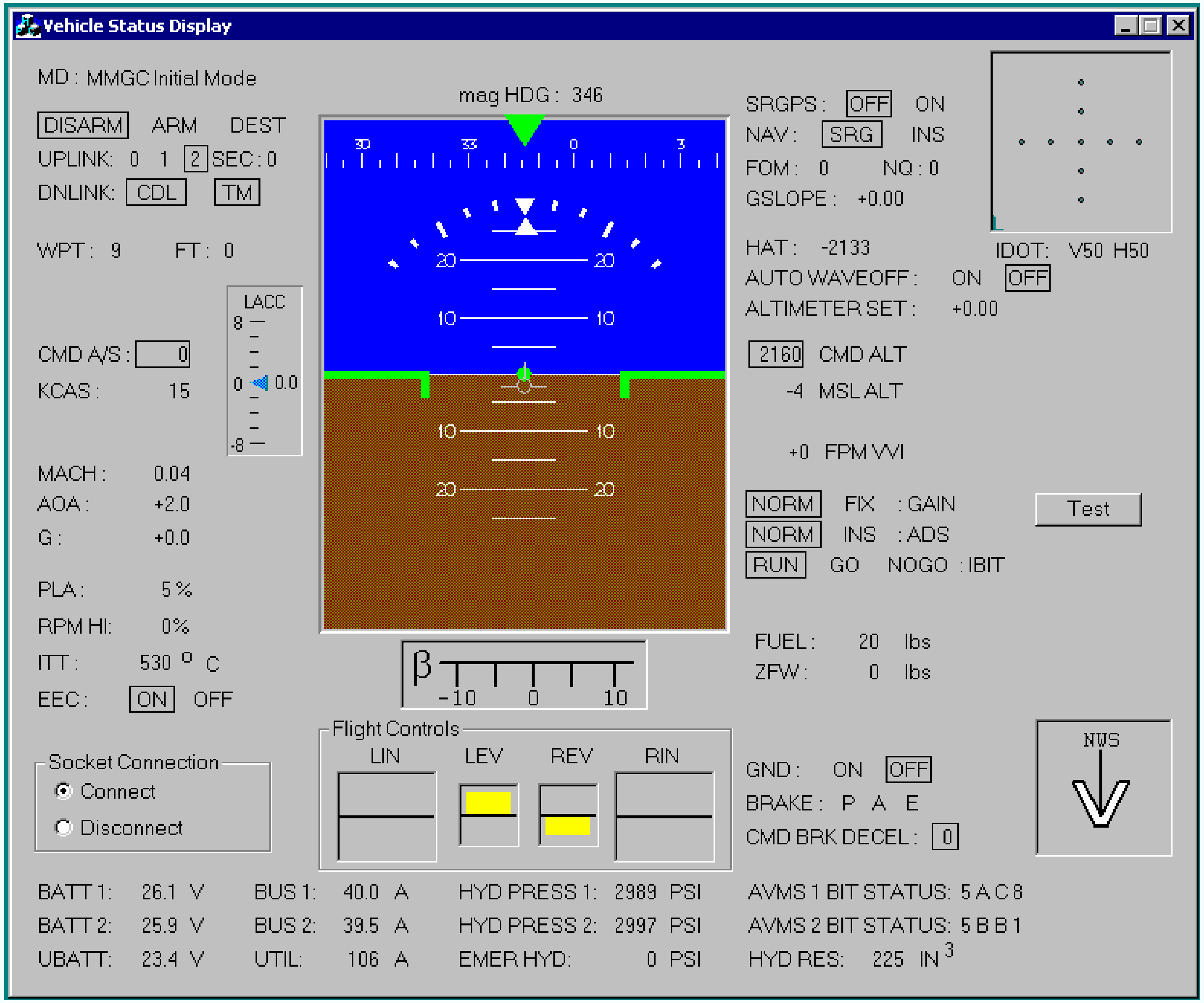


AVO Systems Monitor Display Requirements

- **Vehicle Status Display**
  - **Monitor Current UAV Attitude, Flight Conditions, Basic System Status**
  - **Monitor Planned UAV Flight Conditions**
  - **Monitor Uplink and Downlink Status**
  - **Feedback That “Commands” Were Received**
  - **Distance to Go to Waypoints – Important**
  - **Telemetry Drop-Outs Are Really Irritating**
  - **Consider Backup Method to TM Downlink (i.e., Command Data Link – Limited Bandwidth)**

NORTHROP GRUMMAN
Integrated Systems

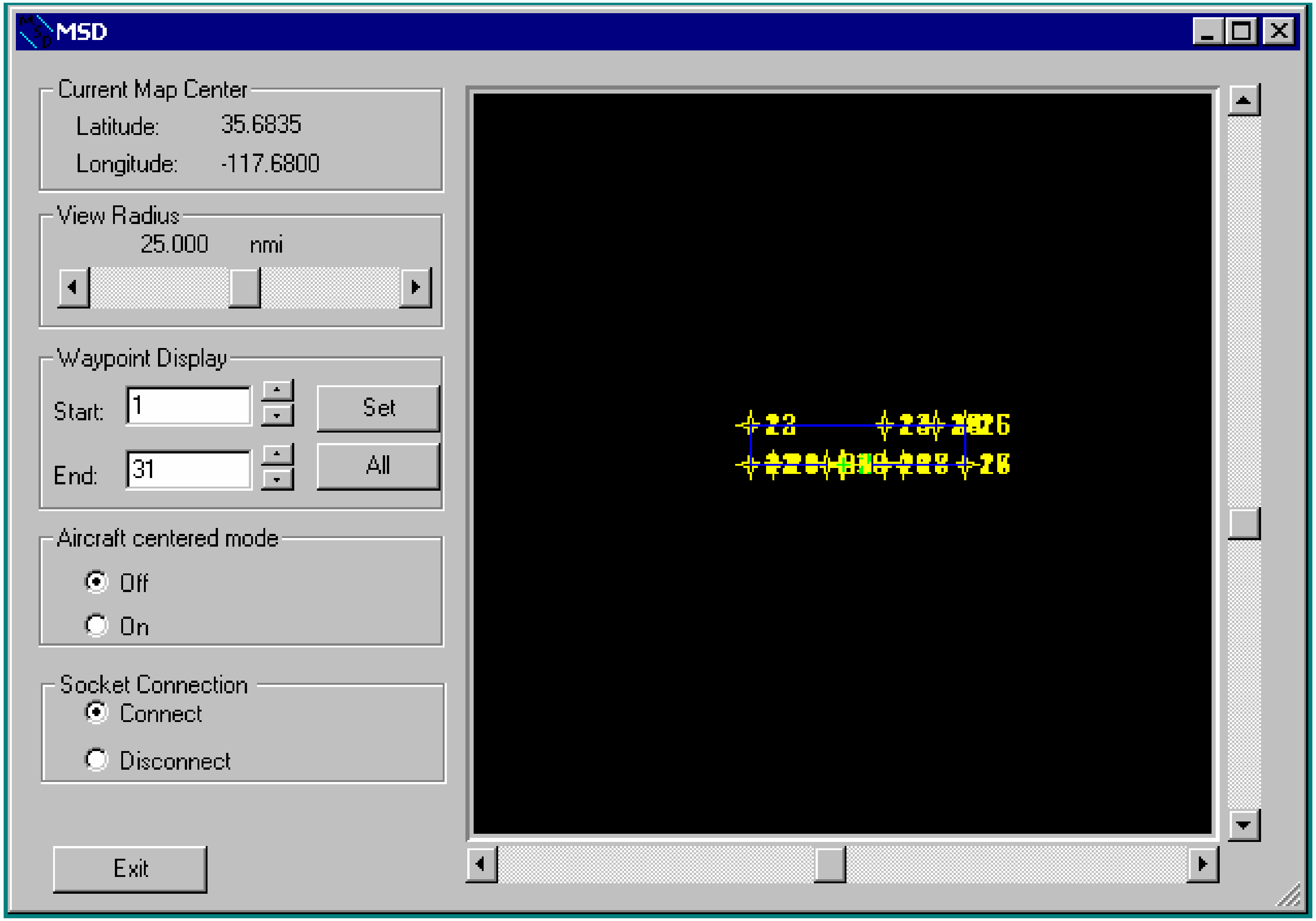
Sample Vehicle Status Display



Mission Situation Display (Range Map)

- Presents "Gods Eye" View of UAV Position in Relation to Planned Mission Track / Waypoints
  – Shows Waypoints / Routes – Both Normal and Contingency Mission Plans
  – Need "Declutter" of Unused Route Segments
  – Need "Quick" Transition to Desired Segments
  – Center on UAV With Ability to Vary Map Size
  – Display of UAV "Track History" Is Very Useful

Sample Mission Situation Display



Surrogate Aircraft Flight Testing

- Manned Aircraft With “Some” UAV Systems Installed
  - Check RF Links (Command and Control / TM)
  - Check RF Links Used by UAV (GPS / Diff GPS)
  - Verify Navigation Software
  - AVO Range Familiarization Is by Product of Testing
- Aircraft Selection
  - Verifying UAV Track Guidance Is Primary Task
  - Replicate UAV Altitude and Airspeed Is Optional
  - Keep It Simple (Display Range Map / Route / UAV Position on Laptop in Aircraft Reduces Aircraft Mods)

Surrogate Testing

- **Testing with Beech Barron Provides the Following:**
  - **Data Link Range Limitations**
  - **Data Link Null Locations**
  - **Profile Link Reception**
  - **Quantitative NAV Performance**
  - **Integrated NAV / Mission Plan / Guidance / Control Verification**

Chase Aircraft

- Both Photo and Safety Chase Requirements
- Practice Airborne Pickup With Control Room
- Chase of Surrogate Aircraft Good Practice
- Consider High / Low Chase for “Agile” UAV
- Thorough Brief With Chase Pilot / AVO Required
- Chase-Control Room Comm Is Very Important
  - Photo Chase KIO Maneuver Must Be Preplanned
  - “T” Word (Terminate) Is Not to Be Used

Contingency Planning

- Develop Useable “What If” Procedures
- What Ifs Should Lead to Limited Preplanned Options:
  - Continue on Mission Plan (or Orbit / Alternate Route)
  - RTB (Following Planned Contingency Routing) Destruct (or Let It Crash)
- Ground Contingencies Are AVO Memory Items
- Defined No Fly Zone – Remaining Range Is OK to Fly
- Practice in Sim with All Engineer Stations Simulated
  - Develop Teamwork Attitude and Build
  - Confidence“Practice Like You Are Going to Play on Flight Day”

First Flight/Lessons Learned

- Plan Short Mission With Limited Objectives
- Follow Go / NoGo Criteria, FOLD, Test Cards
- Have Plenty of Fuel Onboard for Delays
- The “Real World” Contingency That Happens Will Not Be Anything You Planned
- Control Room Engineers Are Your Best WCA
- Remote “Flying” UAVs Requires Same Concentration and Test Discipline as Piloting Aircraft (but It Will Never Replace the “Real Thing”!)

Video of first flight of Pegasus

Individual Protection in a CBRN Environment: Case Studies of the Role of T&E in Requirements Generation

Karen McGrady

karen.a.mcgrady@usmc.mil
Office: 703-617-2441

Presented at the 24th Annual National T&E Conference
Topic area: Requirements Generation Process
and How the T&E Community Can Improve It

Joint Program Manager (JPM) for Individual Protection (IP)

JPM IP is responsible for development, procurement, and sustainment of CBRN environment IP for the Joint Services

The Joint Service General Purpose Mask (**JSGPM**) system has been developed to replace existing masks for ground and shipboard applications. The JSGPM will provide protection against chemical, biological and radiological agents, as well as toxic industrial materials. It is being designed to give the wearer the widest possible field of view, with a lower breathing resistance and weight/bulk less than other masks.

The Joint Service Aircrew Mask (**JSAM**) is being developed in conjunction with the Joint Protective Aircrew Ensemble (JPACE) to replace all current aircrew masks.

Part of the JSLIST Block I ensemble, the **JB2GU FR** will provide hand protection from liquid, vapor, and aerosol CB hazards for users with a flame resistant requirement (ground vehicle crewmen, SOF, Small Boat Teams).

JPM IP Case Studies

Resolution of conflict between requirements and tests designed to demonstrate them:

- **Quantifying and characterizing wear as part of chemical permeation testing (JB2GU FR)**
- **Ability to obtain airworthiness certification in order to complete OT (JSAM)**
- **Quantifying and refining the TIC/TIM threat for IP (JSGPM)**

T&E Community has a role to play in requirements generation

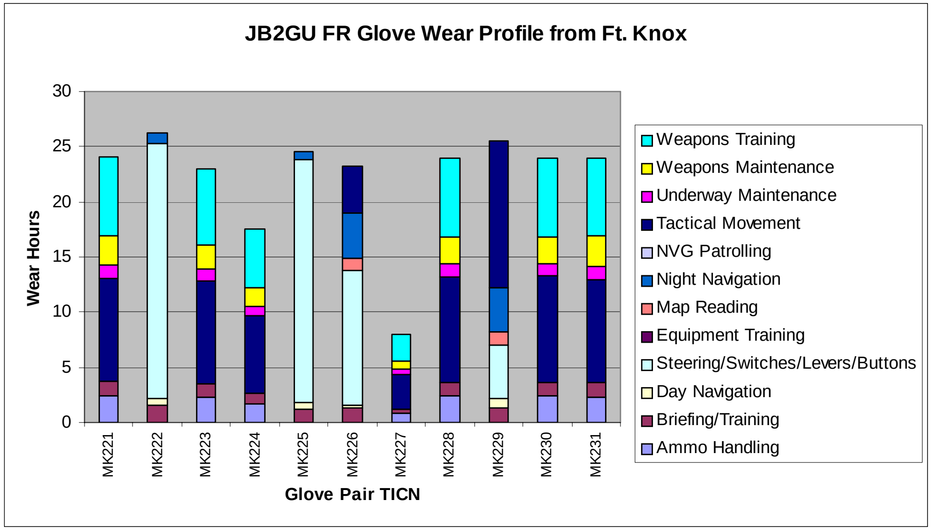
JSLIST Block 2 Glove Upgrade Flame Resistant (JB2GU FR)

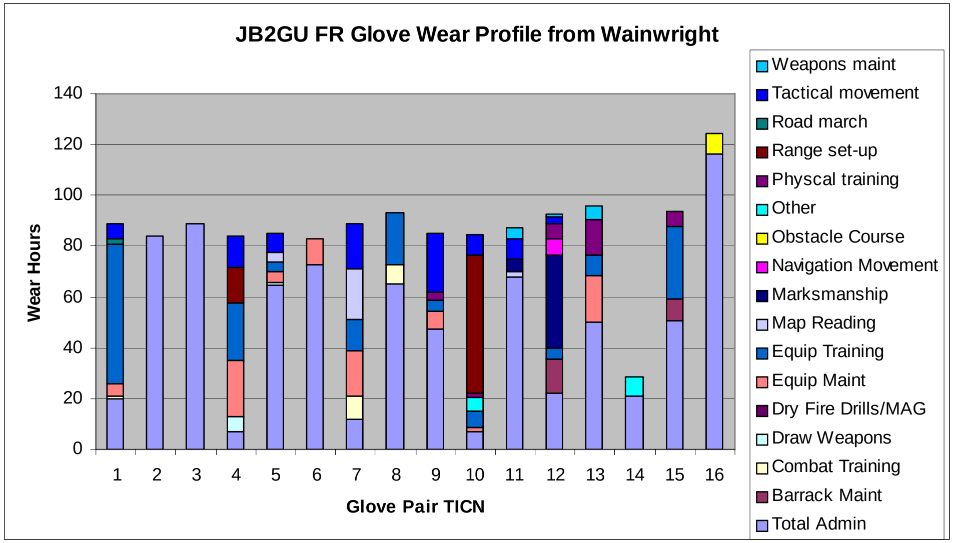
- Requirements indicate the need for chemical protection following "wear" hours
- Practice has been to use representative war fighters—piggy-back training opportunities to maximize "realistic" wear through conduct of mission tasks
- Challenge of data collection and control of test parameters/assets during a training rotation

Wear is a required treatment for every IP system

JB2GU FR Wear Testing

- Need to refine wear requirements; better quantification and data capture
- Not all wear data created equal





Articulate specific type of wear acceptable for the user. Consider mechanical “wear” as part of developmental test events

Lessons Learned: JB2GU FR Wear Testing

- ***Interpretation of the wear requirement***
  - Control of variables for subsequent testing
  - Increased understanding of true capability of the system under test
  - Greater assurance to user community
    - Realistic, representative wear
- ***More powerful results, increased correlation between stresses applied to system and subsequent system performance***

Joint Service Aircrew Mask (JSAM)

Key performance parameters met—obstacles to OT execution:

- **Air worthiness criteria and "safe-to-fly" certification—service specific requirements for Navy, Army, Air Force**
- **Multiple configurations on multiple platforms (rotary and fixed wing)**
- **Structure T&E events to address airworthiness in increments (configurations) up front and early**

Airworthiness certification required to conduct OT for aviation systems

Lessons Learned: JSAM

- ***Close co-development of requirements and T&E structure in future efforts***
  - **Joint Experimentation—field representative DT-type experiments to identify integration and flight issues early in program**
  - **Collaboration, cooperative experimental design, analysis**

- ***Airworthiness criteria addressed upfront and early***
  - **Structure T&E events to address airworthiness in increments (configurations)**

Joint Service General Purpose Mask (JSGPM)

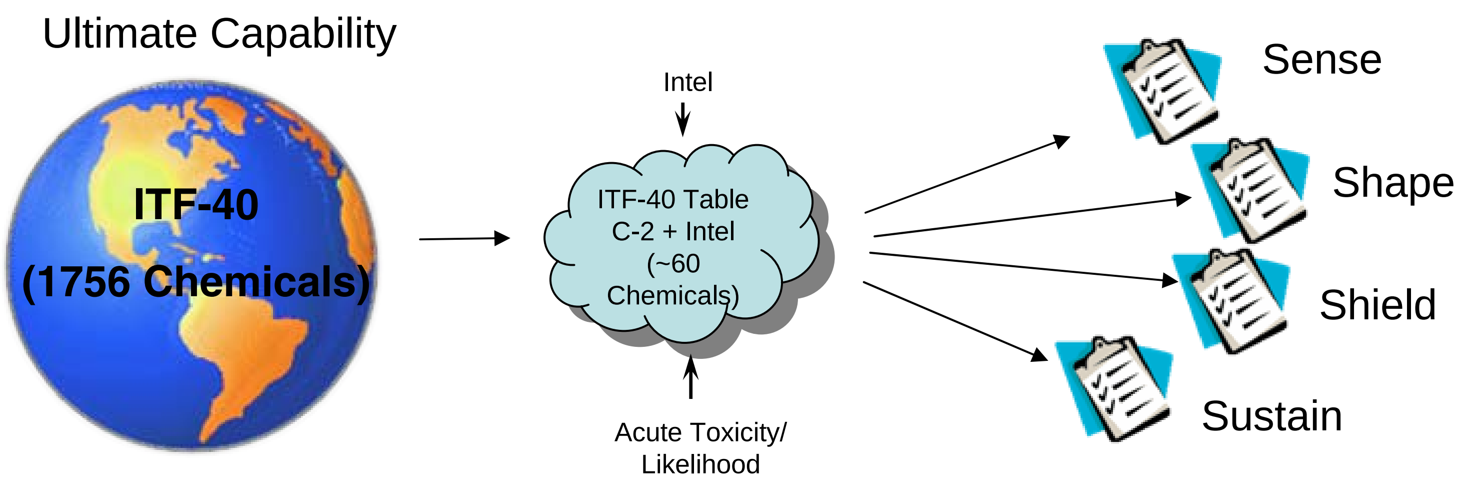
Emerging threats (TICs/TIMs) impacting systems at all points in the acquisition cycle

- **Existing guidance has been the ITF-25 list—not all chemicals have the exposure potential and chemical properties to make them viable threats**
- **JPEO requirement refinement—defining TICs/TIMs of interest based on prioritization strategy**
  - **Cost, schedule, performance control**

Lack of threat definition for TIC/TIM environment impacting the ability to verify operational effectiveness

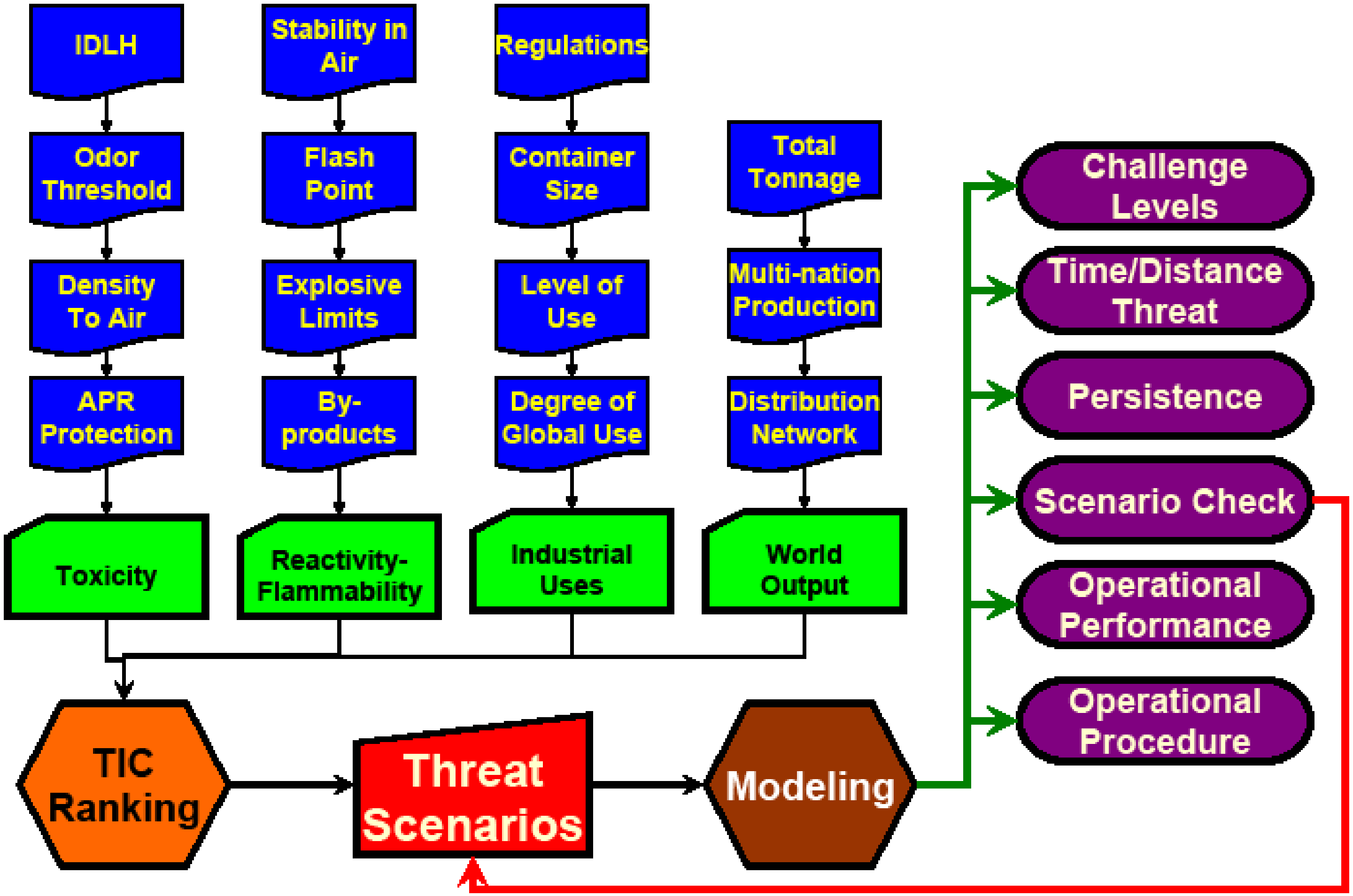
TIC/TIM Task Force

- **Generate specific capability area lists**



- **Generate vignettes to support operational hazard analysis, CONOPS development, and test planning.**

Approach to Requirement Refinement



Lessons Learned: JSGPM

- ***Requirement refinement necessary to direct future efforts***
  - **Assure prudent investments in technology**
  - **Better characterize current system performance**
- ***Augment redefinition of requirements across CB commodity areas***
  - **Approach translates to development of materiel solution for detection, collective protection, decontamination**
- ***Direct T&E infrastructure investments for future test needs***

Conclusion

- *JPEO CBD directs JPMs to actively engage in requirements processes:*
  - To insure clear understanding of the operational need
  - To prioritize limited resources
  - To understand the needs for technology insertion and future capabilities
  - To insure the existence of adequate test methodologies and facilities

Our successes in T&E are helping to refine, improve, and drive requirements generation

Point of Contact

Primary:

Dr. Karen McGrady
Director, Test and Evaluation, Joint Project Manager for Individual Protection (JPM IP)
Email: karen.a.mcgrady@usmc.mil
Phone: 703-617-2441
Address: Stafford, VA 22556

Alternate:

Mrs. Chris Susman
SURVICE Engineering Company
Email: chris@survice.com
Phone: 410-273-7722
Address: 4695 Millennium Drive, Belcamp, MD 21017-1505

NORTHROP GRUMMAN
DEFINING THE FUTURE

Lessons Learned in Fielding a UAS in the Combat Theater

NDIA 24th National Test and Evaluation Conference
Palm Springs, California

February 28th, 2008

Sam McKeehan
System Test Engineer – Global Hawk
Northrop Grumman Corporation

Introduction

I have been deployed five times in support of the Global War on Terror since September 11th 2001.

Supported Operation Enduring Freedom, Operation Iraqi Freedom, and Operation Southern Watch.

I supported the RQ4A "Global Hawk" High Altitude Long Endurance aircraft during these deployments.

These are some lessons learned that have since evolved into standard operations today.

Lessons learned Topics:

1. Pilot Intervention
2. Ground Crew
3. Environment
4. Need in the field
5. Risk of aircrew

AV3 Returning Home

1. Pilot Intervention

- **The Fully Autonomous Air Vehicle**
  - Pre launch
  - Mission plan
  - Command and control
- **Command Shelter**
  - Hand off
  - Aircrew cycle
- **Pre Brief/ Post Brief**
  - Identify possible issues
  - Clarify mission need
  - Accurate fault or discrepancy description

1.1 The Fully Autonomous Air Vehicle

- **Pre Launch**
  - Preflight A/C and Shelter
  - Walk around
  - Outside impacts
- **Mission Plan**
  - A/C and Shelter Match
  - Last minute updates
- **Command and control**
  - LRE (Launch and Recovery Element)
  - Control Center
  - MCE (Mission Control Element)

NORTHROP GRUMMAN

1.2 Command Shelter

- **Hand off**
  - LRE launch
  - MCE Mission
  - LRE Recover
- **Aircrew cycle**
  - LRE
  - MCE
  - Crew rest

NORTHROP GRUMMAN

1.3 Pre Brief / Post Brief (Pilots)

- **Identify possible issues**
  - Intermittent issues
  - Scheduled Maintenance
  - Known Comm/NAV interference
- **Clarify mission need**
  - SAR, EO/IR
  - Ground CDL
- **Accurate fault or discrepancy description**
  - Faults during mission
  - Post flight/mission data review

2. Ground Crew

- **Preflight and Post flight**
  - Inspections
  - Mission plan
  - Fault logs
- **Scheduled Maintenance**
  - Down time
  - Mission Cycle
- **Pre Brief/ Post Brief**
  - Identify possible issues
  - Clarify mission need
  - Accurate fault or discrepancy description

2.1 Preflight and Post flight

- **Inspections**
  - Electrical (VTC)
  - Mechanical
  - Servicing
- **Mission plan**
  - Loading
  - Check sum
- **Fault logs**
  - Download and save
  - Erase for new mission
  - Fault Isolation

NORTHROP GRUMMAN

2.2 Scheduled Maintenance

- **Down time**
  - Minor/Major
  - Equipment
  - Retest
- **Mission Cycle**
  - Schedule
  - Impact to next

Approved for Public Release, Distribution Unlimited,
WPAFB 08-0222 Dated 5 February 2008

2.3 Pre Brief / Post Brief (Ground Crew)

- **Identify possible issues**
  - Recurring faults
  - Work a rounds
  - Mission cancel
- **Clarify mission need**
  - Payload(s)
  - Keying Requirements
- **Accurate fault or discrepancy description**
  - Trouble shooting time
  - Fault isolation
  - Lead time on replacements

NORTHROP GRUMMAN

3. Environment

- **Climate**
  - Maintenance time
  - Indoor/Outdoor
  - Mission Capable Limits
- **Equipment**
  - Availability
  - Special Equipment
- **Part replacement**
  - Hours on airframe
  - Lead Time.

Approved for Public Release, Distribution Unlimited,
WPAFB 08-0222 Dated 5 February 2008

3.1 Climate

- **Maintenance time**
  - Exposure to elements
  - Coincide with mission
  - 24 hour coverage
- **Indoor/Outdoor**
  - Time
  - Exposure to others
- **Mission Capable Limits**
  - Take off/ Landing
  - Visibility over target

3.2 Equipment

- **Availability**
  - On site
  - Loan from local unit
  - Sent from stateside
- **Special Equipment**
  - For that area
  - Power source (s)
  - COMSEC

NORTHROP GRUMMAN

3.3 Part replacement

- **Hours on airframe**
  - Increased cycle
  - Cost
  - Expand limits
- **Lead Time.**
  - Availability
  - Customs
  - Local Vendor

NORTHROP GRUMMAN

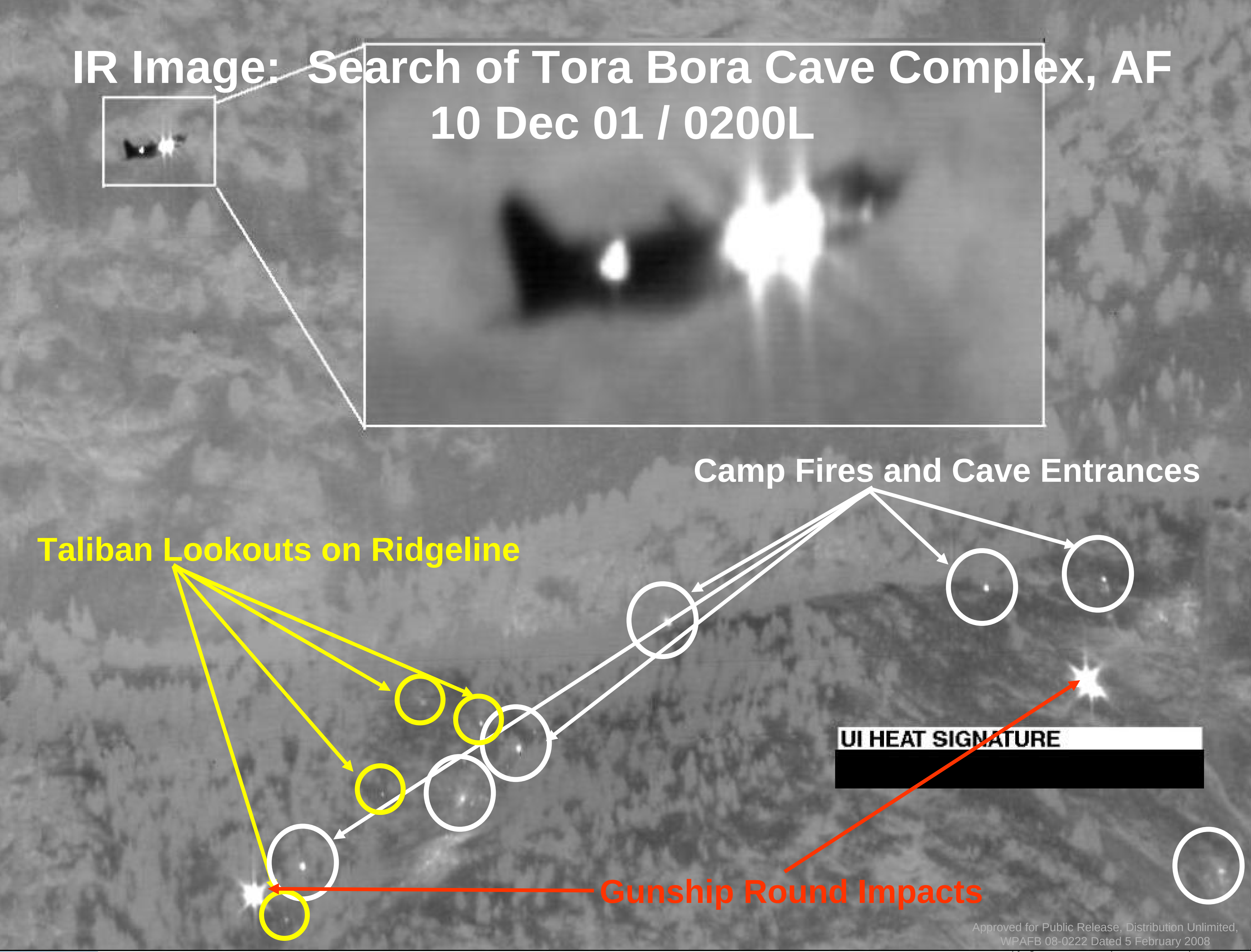
4. Need in the Field

- **Battlefield Commander**
  - Near real time Imagery
  - BDA
  - Re Direct
- **Troops on Ground**
  - More Intel
  - Direct download
- **Long Endurance**
  - Time in Theater
  - On Task
  - Flexibility

NORTHROP GRUMMAN

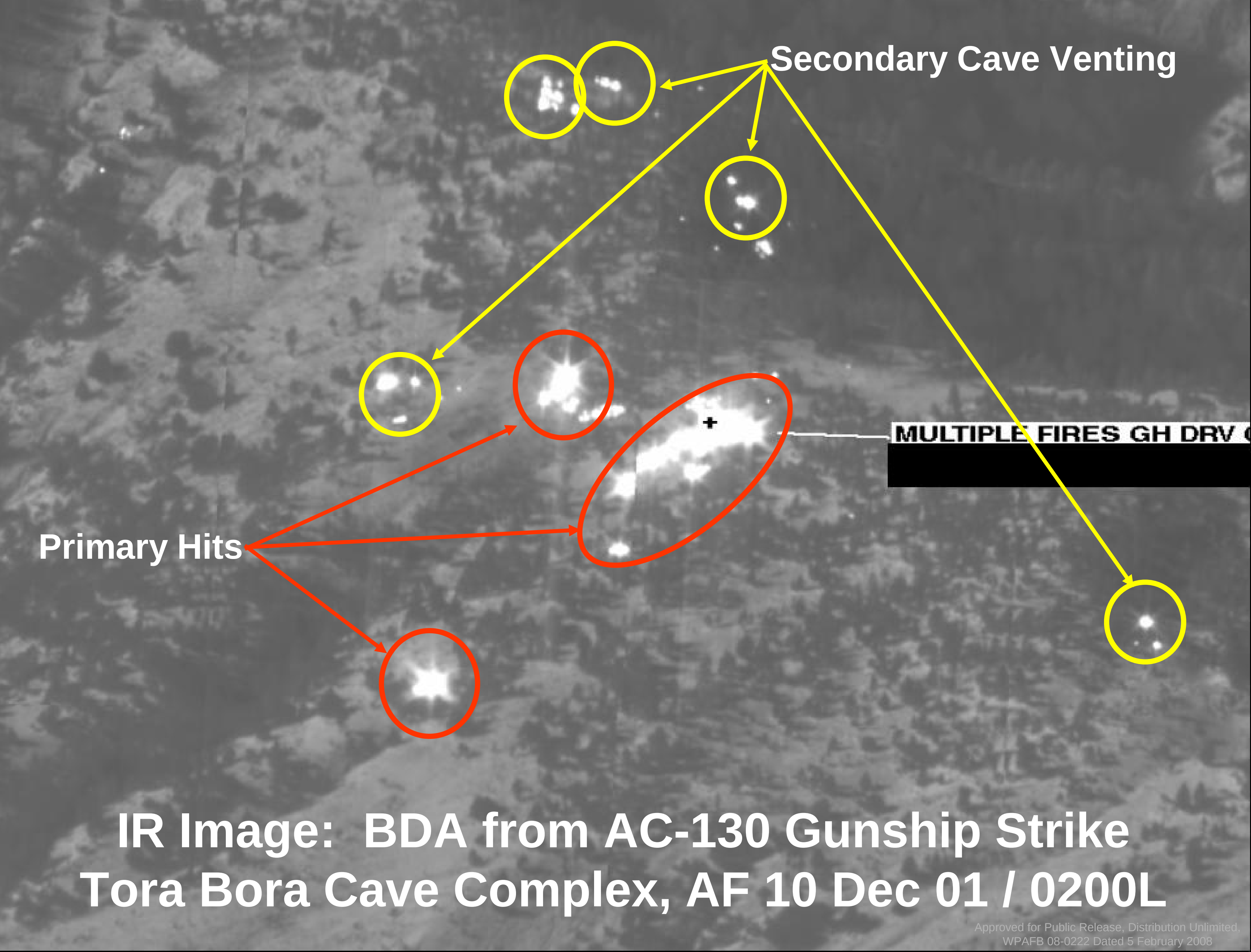
4.1 Battlefield Commander

- **Near real time Imagery**
  - Accurate ground troop placement


IR Image: Search of Tora Bora Cave Complex, AF
10 Dec 01 / 0200L
Camp Fires and Cave Entrances
Taliban Lookouts on Ridgeline
UI HEAT SIGNATURE
[redacted]
Gunship Round Impacts

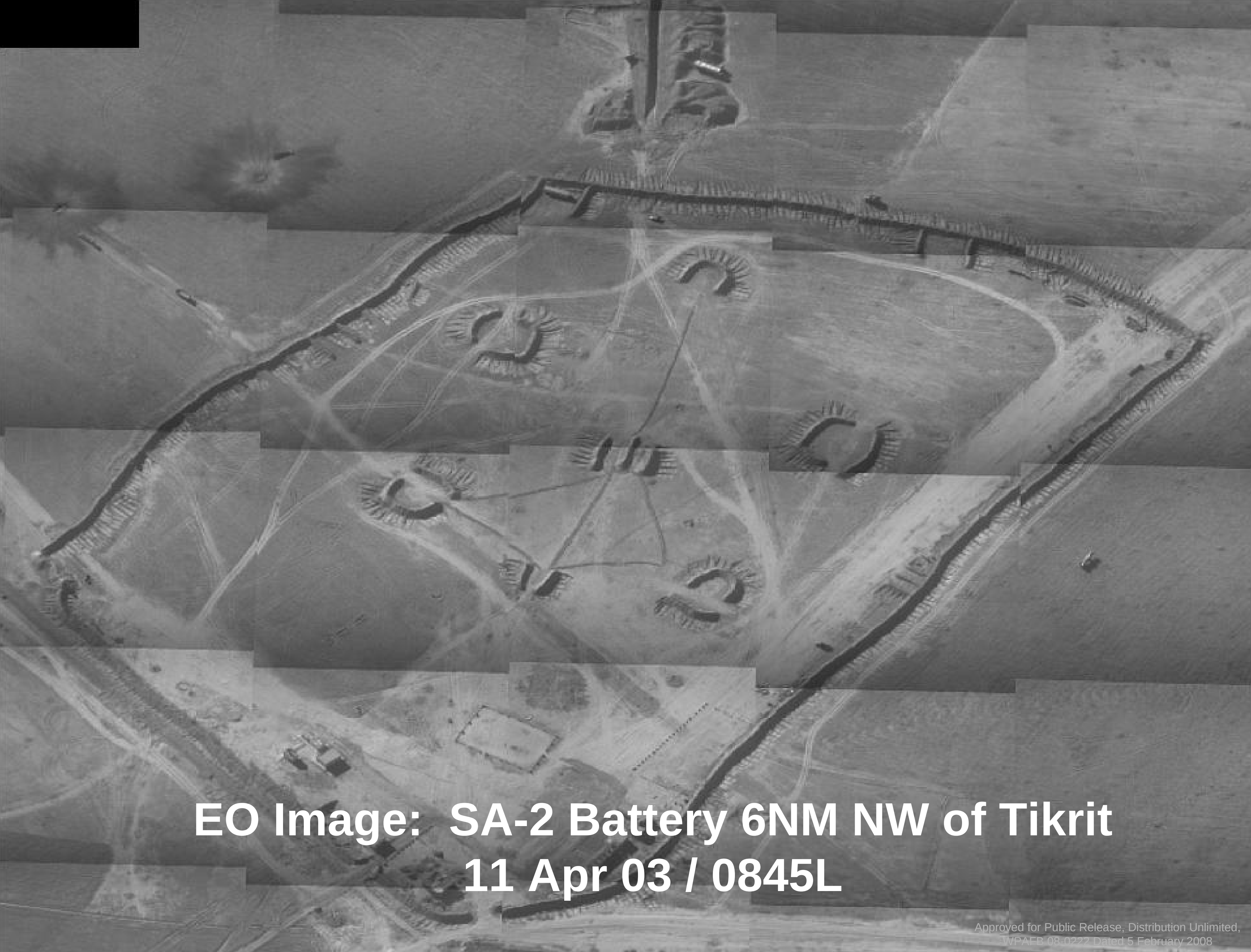
4.1 Battlefield Commander

- **Near real time Imagery**
  - Accurate ground troop placement
  - Air strike


Secondary Cave Venting
MULTIPLE FIRES GH DRV
[redacted]
Primary Hits
IR Image: BDA from AC-130 Gunship Strike
Tora Bora Cave Complex, AF 10 Dec 01 / 0200L

4.1 Battlefield Commander

- **Near real time Imagery**
    - Accurate ground troop placement
    - Air strike
    - Potential threats


EO Image: SA-2 Battery 6NM NW of Tikrit
11 Apr 03 / 0845L

4.1 Battlefield Commander

- **Near real time Imagery**
  - Accurate ground troop placement
  - Air strike
  - Potential threats
- **BDA**
  - Verification
  - New targets
- **Re Direct**
  - Capable to look outside of mission
  - Determined by BDA
  - Target of opportunity

IR Image: Eastern Afghanistan
02 May 02 / 0700L

4.2 Troops on Ground

- **More Intel**
  - Local Threats
  - BDA
  - Re Direct

- **Direct download (Demo)**
  - Hand held's
  - portable ground stations

Approved for Public Release, Distribution Unlimited, WPAFB 08-0222 Dated 5 February 2008

4.2.1 Ground Laptop Interface (Demo)

4.3 Long Endurance

- **Time in Theater**
  - 19 to 30 hours (Average 24)
  - Distance from target area
- **On Task**
  - Coverage of active mission
  - Ongoing BDA

- **Flexibility**
  - To complete several missions
  - Support other Recon aircraft
  - Aircrew limitations

NORTHROP GRUMMAN

5. Risk of Air Crew

- **Pilot Fatigue**
  - Long Missions
  - Crew rest
  - Crew cycle
- **Ground Station**
  - Location
  - Flexibility
  - Divert safety

Safe at home station

Conclusion

- *Performance =95.8% single A/C turn around 4 hours.*
- *Efficiency =91% example:* **40 consecutive missions 100%**
- *Awards = Over a dozen and counting.*

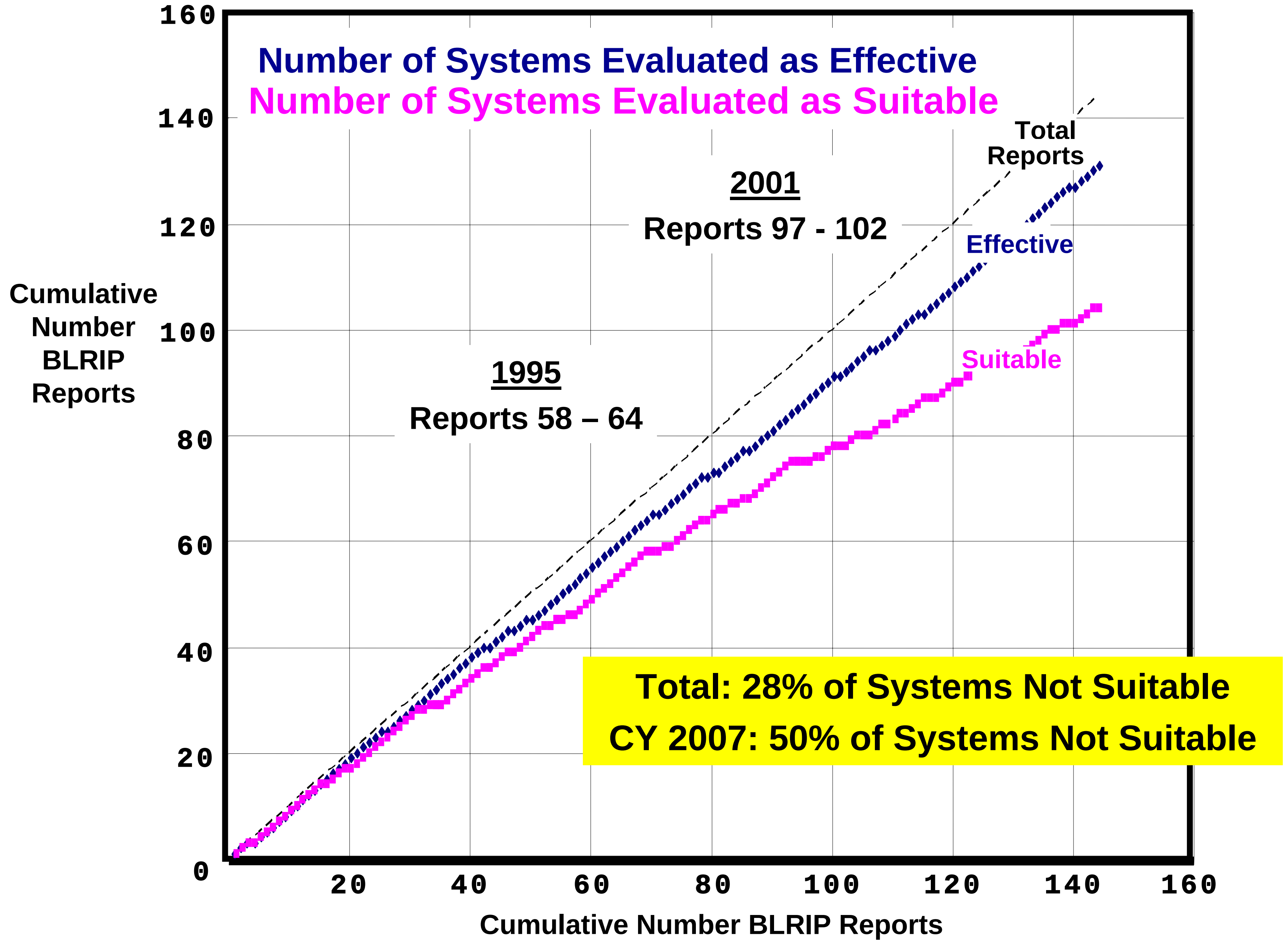
NORTHROP GRUMMAN

Questions

OPERATIONAL TEST AND EVALUATION • DIRECTOR •

KEY TO WEAPONS THAT WORK

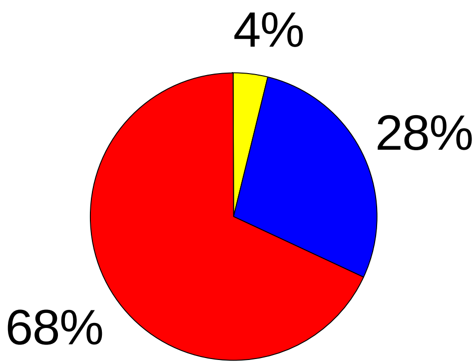
Cumulative IOT&E Results Through FY 2007



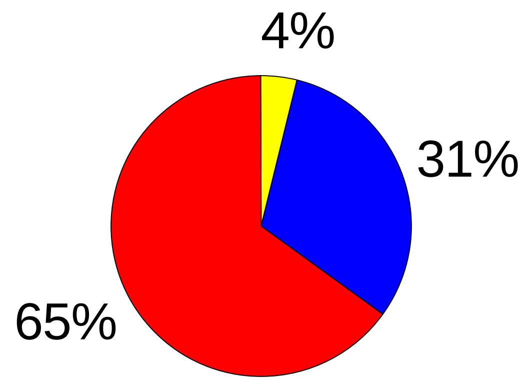
Why DOT&E is Focusing on Reliability

DoD O&S Costs - Largest Fraction of Life Cycle Costs

Ground Combat Systems

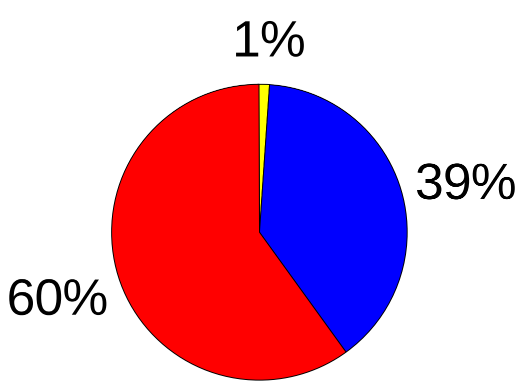


Rotary Wing Aircraft

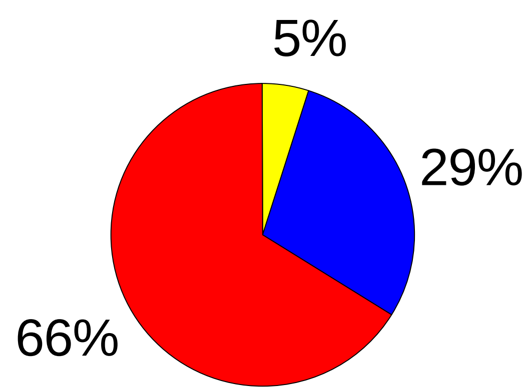


*** Source: OSD CAIG**

Surface Ships



Fighter Aircraft



RDT&E **Procurement** **O&S**

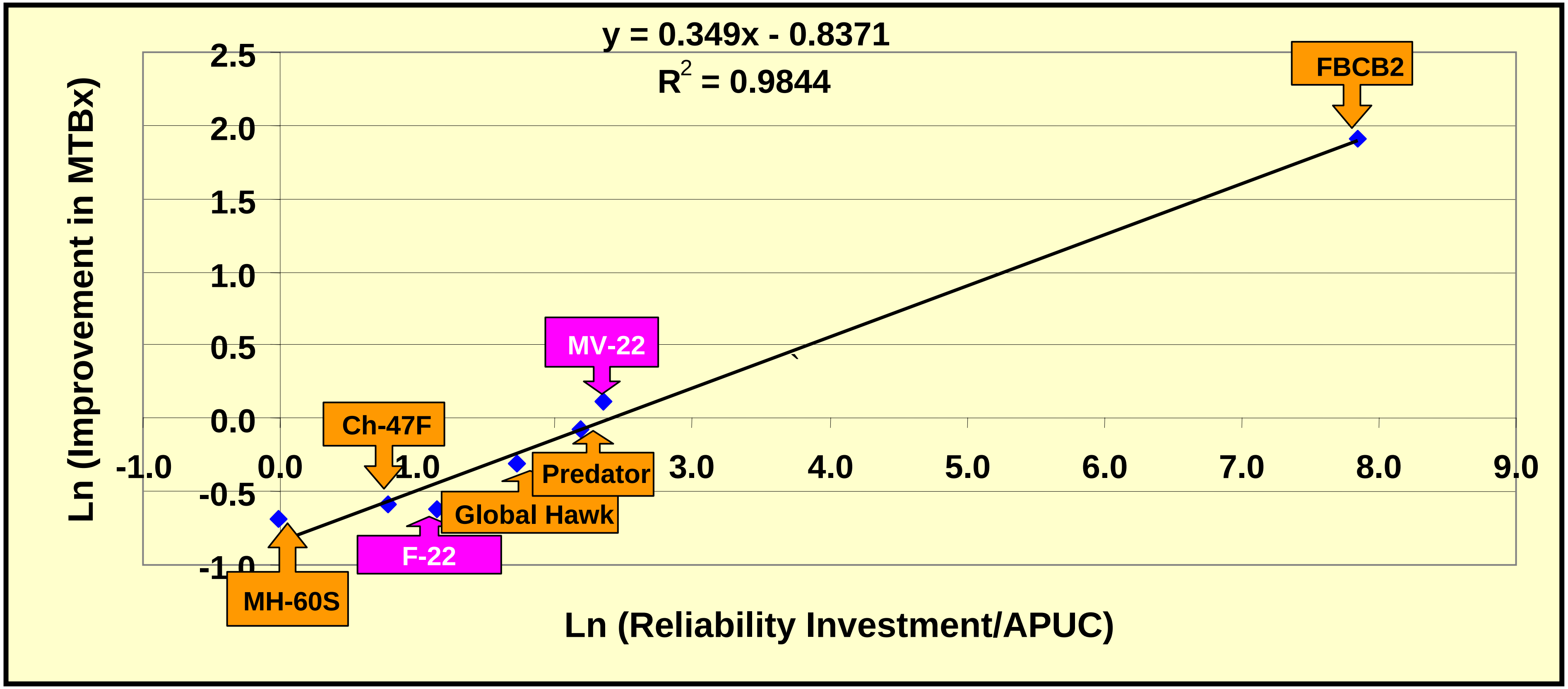
Why DOT&E is Focusing on Reliability

"We have a tendency to look at what it takes to get a program out the door. We don't think too much about what the life cycle [cost] is. It's 'Can I build it?' I would like us all to be mindful of what it costs to operate whatever we are building for whatever its life is going to be because I have to pay that bill every single year.“

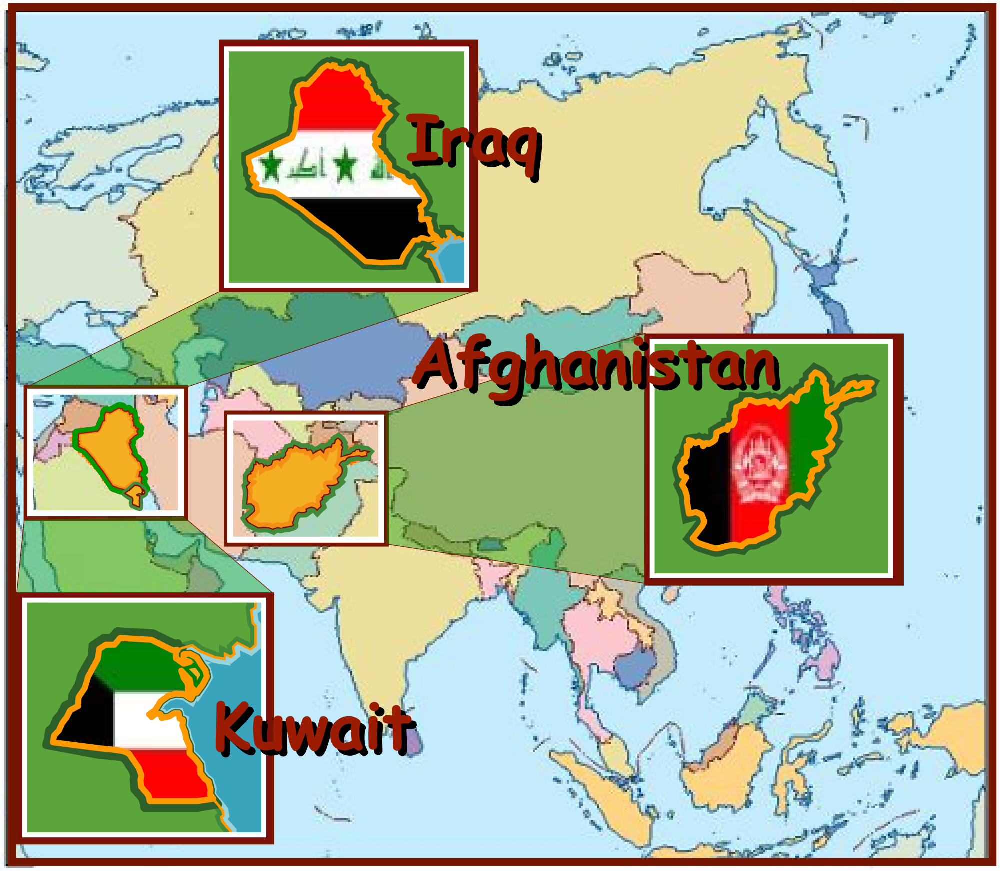
(CNO, ADM Michael G. Mullen in an interview with "Government Executive" magazine May 15, 2006)

Empirical Relationship of Studies

Reliability Investment & Reliability Growth



ATEC Forward Operational Assessment Team



AGENDA

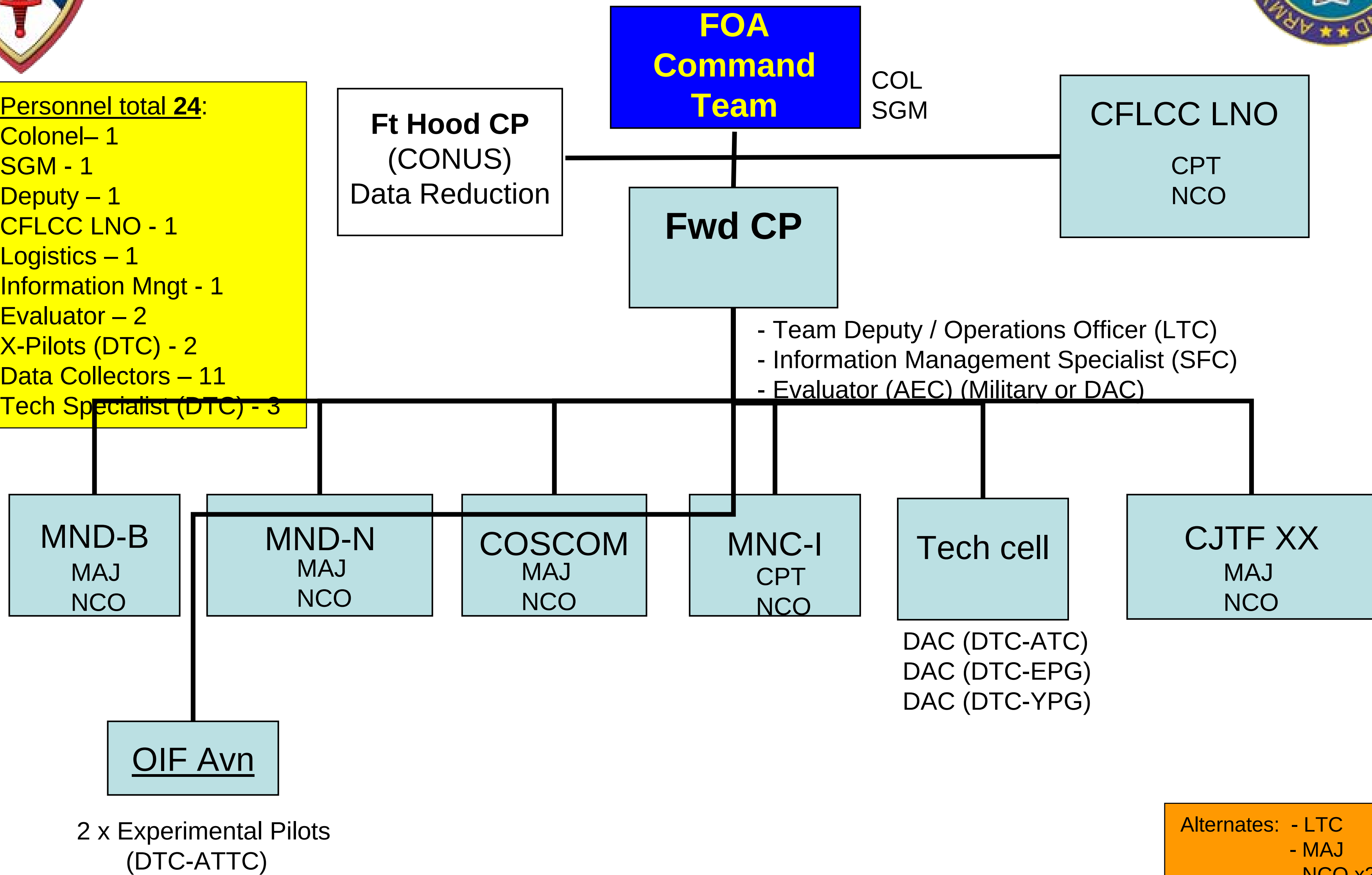
- Mission
- Team Composition
- Primary Functions
- ATEC Theater Integration
- ATEC FOA Team Facts
- Contributions
- Questions/Comments

ATEC FOA Mission

The United States Army Test and Evaluation Command (ATEC) Forward Operational Assessment Team deploys to CENTCOM to conduct liaison with MNC-I, CJTF-XX, CFLCC, and CENTCOM in order to plan, coordinate and integrate forward assessment, operational testing, evaluation and experimentation of selected systems.

FOA Team Composition

<u>Personnel total **24**</u>:
Colonel– 1
SGM - 1
Deputy – 1
CFLCC LNO - 1
Logistics – 1
Information Mngt - 1
Evaluator – 2
X-Pilots (DTC) - 2
Data Collectors – 11
Tech Specialist (DTC) - 3



Alternates: - LTC
- MAJ
- NCO x2
- DAC

Primary Functions

- Liaise with commands in theater
- Collect data and report on specified systems
- Conduit of information between theater and CONUS
- Provide ATEC HQs with theater priorities for testing in CONUS

ATEC Fwd Integration

JIEDDO-Iraq
JCCS-I
REF-Iraq
AMC FAST
AMC Fld Spt Bde
AMC LNO
HQDA G8 LNO
PEO C3T LNO
PEO IEWS LNO
Fielding PMs

Iraq

CJTF Troy
MNF-I S&T
MNC-I C3 INTEGRATION
MNC-I FORCE MOD
MNC-I C2 OPS
MNC-I C4
MNC-I EWCC (G)
MNC-I KMO
MNC-I C7 EHCC
CEXC
MNC-I C-RAM LNO

Kuwait

ASA(ALT) LNO
HQDA G8 LNO
REF-Kuwait
AMC-Kuwait
CFLCC C3

Afghanistan

JIEDDO-A (TF Paladin)
JOINT CREW OFFICE
REF-A
CJTF XX FMD

ATEC FOA Team Facts

- ATEC presence in theater for 3+ years
- Collected data and reported data on 200+ systems
- Significant contributions to up-armoring efforts
- Significant contributions in EW system performance and interoperability

The Most Important Contributions

- Getting system capabilities and limitations to leaders
- Linking in-theatre leadership and their issues back to CONUS
  - Testing priorities
- Technical expertise on the ground helping to solve challenges
  - Ballistic properties of armoring solutions
  - Electronic countermeasure system support
- Total ATEC effort to support the theatre on armoring efforts

COMMENTS/QUESTIONS

LOCKHEED MARTIN

Improving T&E Participation in the Requirements Generation Process

Chuck Burdick & Keith Montgomery
Lockheed Martin Simulation, Training & Support

Paul Bross
Lockheed Martin Center for Innovation

Presentation #6448

"The Role of the T&E Community in the Requirements Process"

Requirements Generation

- The Government regularly conducts analysis to determine requirements, select system capability parameters, perform cost-benefit trade-offs, etc.
  - Analysis is a critical element in providing capable, cost effective solutions suitable to requirements
- To support this analysis, the analytical community maintains several models and simulations of future warfighting threats and capabilities
  - Most studies are tied to legacy Service models
  - Threat and System data sets are updated regularly

Requirements Analysis & Simulation

- Typically, for an OSD sponsored study of capabilities, each Service or major DoD Agency provides one or more simulations of preference. For example:
  - Thunder/STORM for the Air Force,
  - ITEM for the Navy,
  - JICM for the Army
  - EADSIM for Missile Defense
  - COSMOS/SEAS for Intel
  - ELIST for Logistics
  - MIDAS for Strategic Lift
  - Pythagoras for SOF
- These simulations are readily available, but obtaining the data for representing friendly forces, threat forces, and the situation 10 or 20 years out for each of the models has been a challenge
- To address this, the OSD Analytical Community* has developed the Analytical Agenda, a collaborative analytical framework, to examine Defense Strategy and Capabilities requirements along with a common source of credible data, the Joint Data Support (JDS) Office

* Office of the Sec of Def (Policy), JCS J8, and OSD PA&E

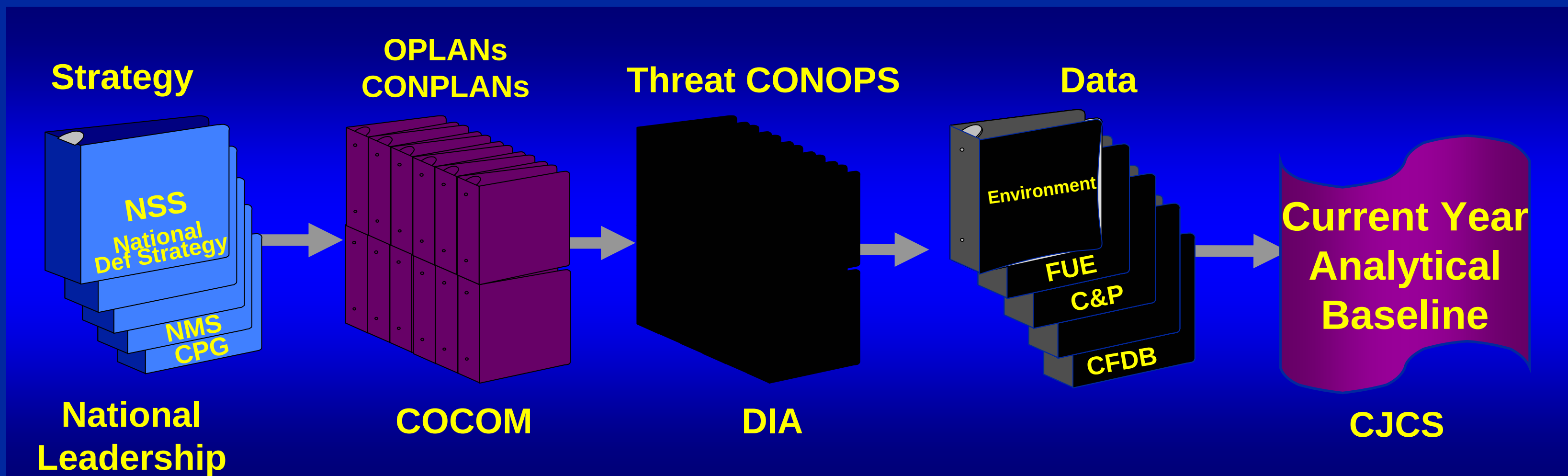
Analytical Agenda Tenets

- **Make analyses more effective and relevant for decision-making**
  - Focus debate on assumptions and issues
  - Help synchronize strategic planning activities throughout DoD
- **Provide a common starting point for joint analyses**
  - Scenarios characterize the range of defense challenges
  - Future joint warfighting CONOPS are developed/examined
  - Analytic assessments (baselines, data, and studies) are accessible and well documented
- **Support a collaborative, transparent, and continuously ongoing analytical process with the Services, COCOMS, Joint Staff, and OSD involved**
  - Train and sustain a critical mass of analysts
  - Managed by OSD Policy, Joint Staff, and PA&E

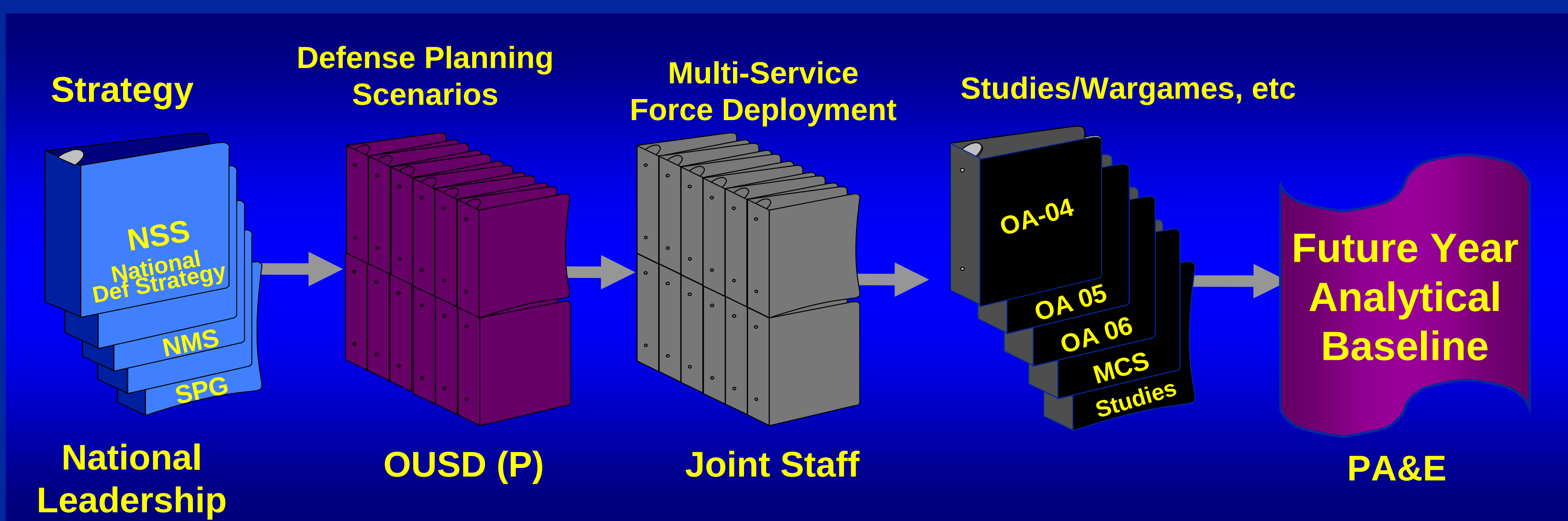
Create a Common Simulation Environment for Planning, Programming, Acquisition, Testing, Experimentation, and Training

Analytical Baseline Process

Current Year:



Future Year:

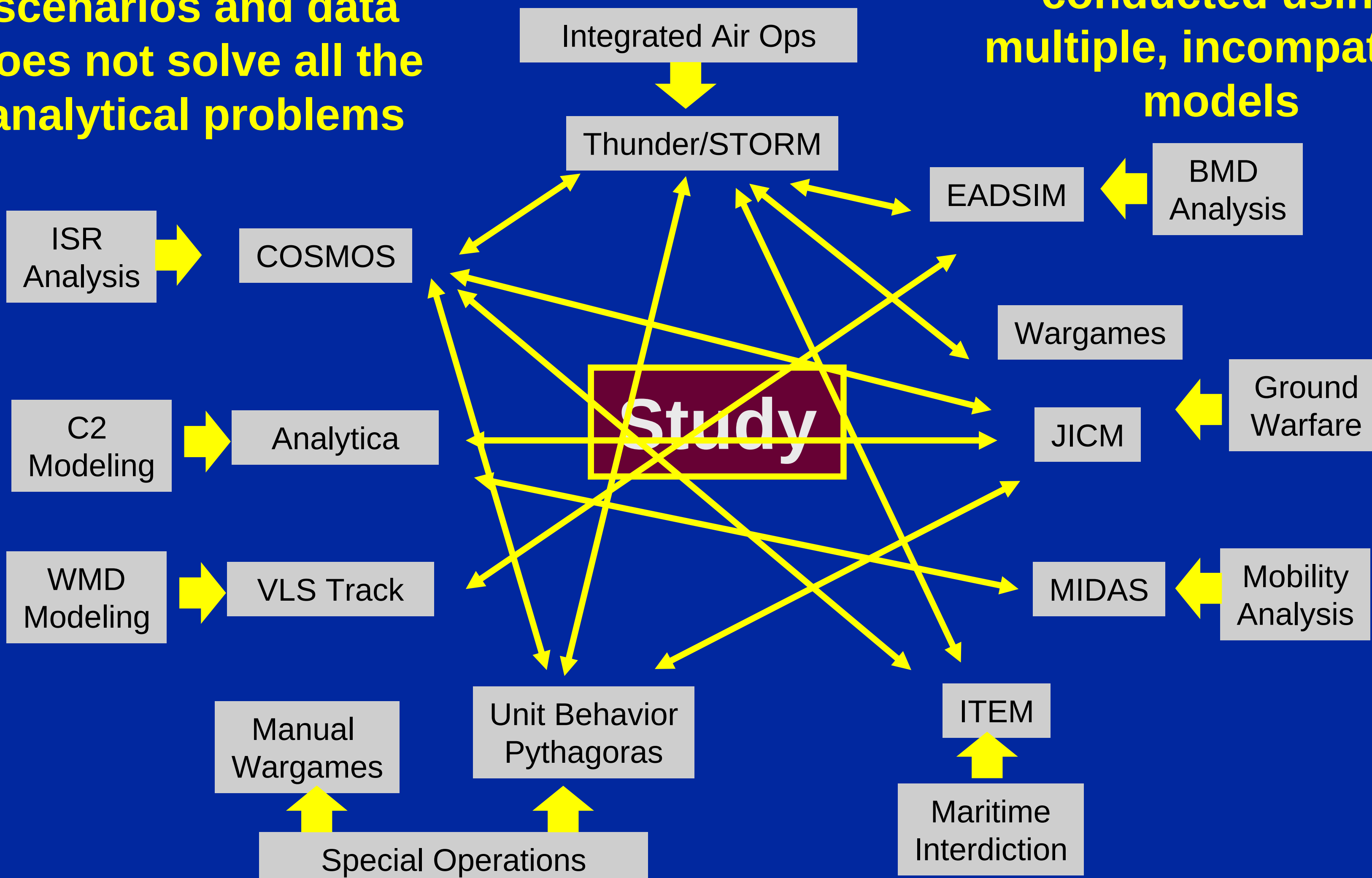


LOCKHEED MARTIN

Conducting a Study with Multiple Models

Having common scenarios and data does not solve all the analytical problems

Most studies are conducted using multiple, incompatible models



Analytic Community Models

Joint Data Support

UNCLASSIFIED DISPLAY

Expand All - Collapse All

- Home (U)
- What's New (U)
- Analytic Agenda (U)
- Scenarios (DPS, MSFD, AB) (U)
- Studies (U)
- Forces, Units, Equipment (U)
- M&S Tool Registry (U)
- Reference Data and Links (U)
- Archived Products (U)
- JDS Web Site Access (U)
- JDS Forums (U)
- Acronyms and Abbreviations (U)
- Suggestions and Feedback (U)
- About JDS (U)

UNCLASSIFIED DISPLAY

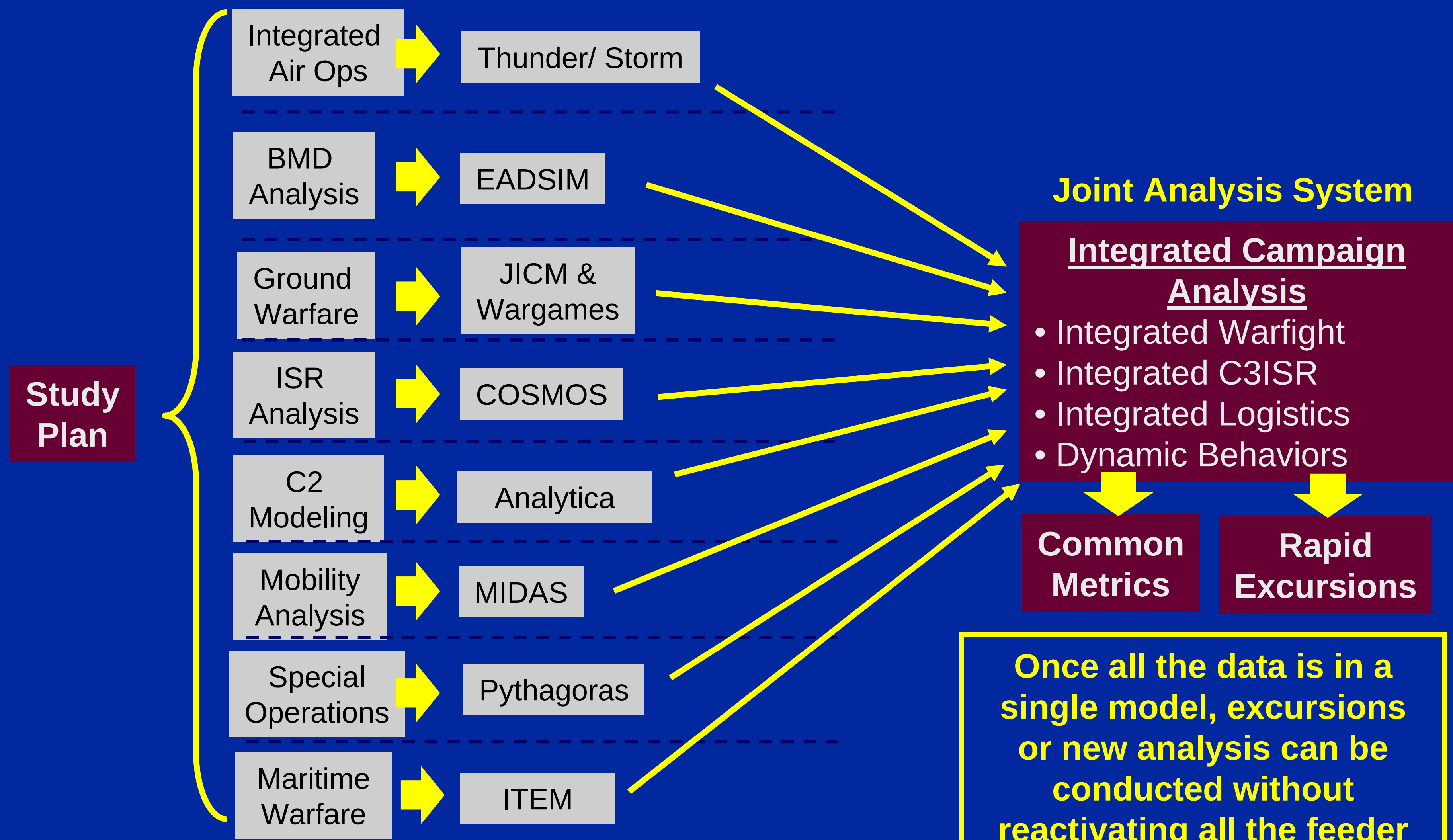
Strategic Analysis M&S Toolkit Tool Classification

Tool	Planning		Traditional Force-on-Force			C4ISR			Mobility and Logistics				WMD		Non - Traditional	
	Adaptive Planning	Effects Based	Air Power	Ground	Maritime	C2	COMM	ISR	Force Allocation	Logistics	Inter-Theater	Intra-Theater	Missile Defense	CBRN	Special Operations	Behavior
Analytical Baseline Tools																
AMP											M	M				
EADSIM			M										M			
ELIST												M				
HPAC														E		
ITEM			C	C	C								C			
JCATS	M			M											M	
JICM			C	C												
MIDAS											M					
THUNDER			C	C	C											
Component Study Tools																
APOD										E	E					
ARCEM											E					
CFAST	M										M	M				
CMARPS											E					
COSMOS						M	M	M					M			
FSST									M							
IGS	C	C	C	C	C										C	C
JAS			C	C	C	C	C	C		C	C	C	C	C		
JFAST	M										M					
JFCT										M						
NETWARS							M									
NSS					C			C					C			
STK							M	M								
SUSGEN										M						
VLS Track														E		

C/Blue is Campaign-level, M/Green is Mission-level, and E/Brown is Engagement-level of detail

Only one model currently stretches across the M&S Toolkit

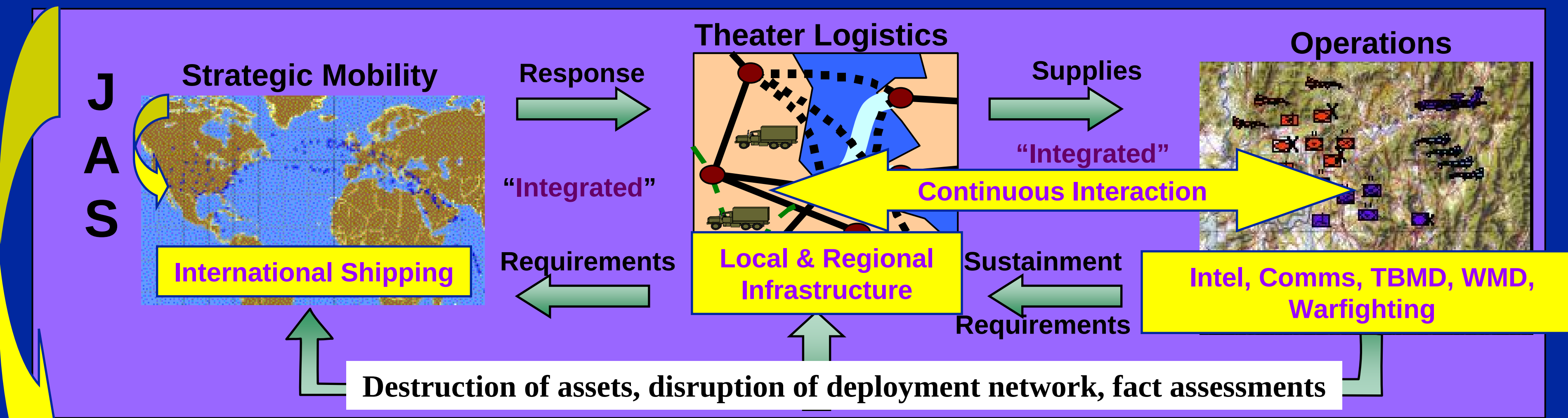
Alternative Analytical Modeling Methodology



Once all the data is in a single model, excursions or new analysis can be conducted without reactivating all the feeder models

Integrated Joint Campaign Modeling

<u>Analysis Paradigm:</u> **All input *integrated* into a single, joint environment**



<u>JAS Paradigm:</u>

All CAPABILITY areas *integrated* in a single, operational environment

<u>Basic Scenario Entities:</u> Forces (US Military, Allies, Neutrals, Adversaries, Terrorists, US Government & Host Nation, Civil Agencies, NGOs/PVOs, Populations)

<u>Intelligence, Perception, and Knowledge Base:</u> Multi-source Collection, prior knowledge, rule sets

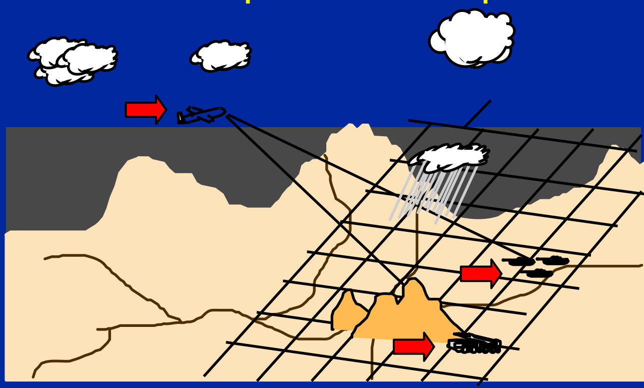
<u>Organization, Directives & orders, Communications) - C2:</u> Multi-actor Info sharing/ tiered dissemination, Rules of Engagement, Decision Process, Communications Interoperability

<u>Response Plans (CONOPS):</u> Range from Facility –> Port –> Region –> National -> Coalition, entities with both common & unique capabilities

<u>Logistics & Support:</u> Support for Civil Authorities; constrained transportation, food, fuel, and shelter

Agent-Based Operations

- BSE -- a friendly unit, enemy unit, or major system operating in the battle space. Examples:
  - Operational Headquarters
  - Support Headquarters
  - Airbases and seaports
  - Infrastructure: Power, H_2O
  - Civilians
  - Land: Units, Neighborhoods
  - Air: Flights, military & civil
  - Maritime: Ships, small craft
  - Space: Sensors & Comms



Effects-based and much faster than Real Time

Basic Scenario Entity (BSE)

Command & Control — "Thinking," Planning, Decision Making

Sensor — Detecting, recognizing, identifying

Resource Account — Tracking the BSE's assets and consumable resources

Platform — Location, speed, direction

Communications Manager — Communications-based interface to other BSEs

Owns or Controls — **BSE**

Event-based, stochastic model providing detailed cause and effect outcomes

JAS C4ISR is Unique

SENSORS → Explicit COMMS → Updated Perception → Decisions* → Actions

- Every Sensor input, including Human Intelligence is recorded
- Ground Truth is simultaneously recorded for comparison

- Over 70 types of operational messages currently employed (could be increased)
- Uses explicit networks with capacities and delays

- Simulates information fusion
- Common Operational Picture maintained
- Sources of all information recorded

- Decisions & Actions are traceable to their underlying information

*
- Every BSE has a basic Command & Control capability appropriate to the BSEs purpose, e.g. explicit headquarters units, artillery unit, supply and transportation unit, etc.) giving a set of allowable decisions.
- A BSE's C2 capabilities are further enhanced by plug-ins which give specific new functionality to either a single BSE or a class of BSEs, e.g. a Supply Planner
- Knowledge Bases are assigned to individual BSEs or classes of BSEs to allow them to employ user-selected facts, rules, and actions.

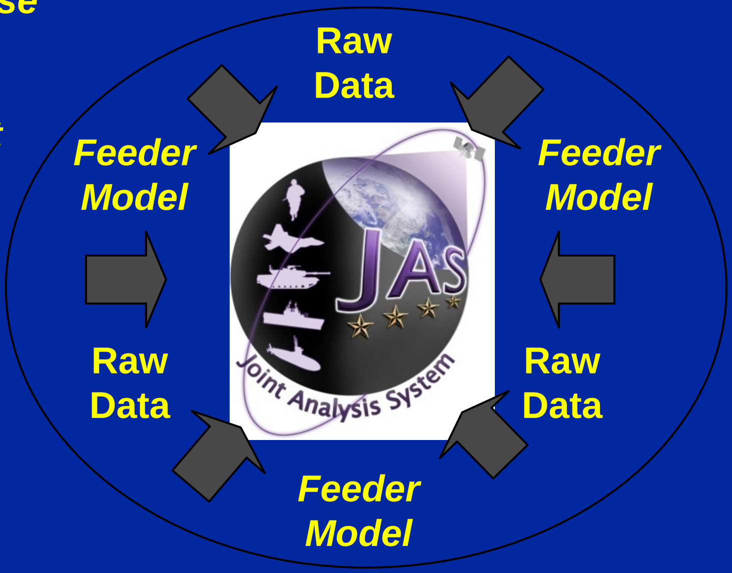
Joint Data Inputs

Synthetic Environment

- *Solar/Lunar*
- *Atmospheric*
- *Sea/Sub Surface*
  - *Transmission Loss*
  - *Ambient Noise*
- *Terrain*
  - *Movement*
  - *Line of Sight*

CONOPS

- Orders & Plans
  - Land/Air/Maritime
  - ISR Collection
  - Any Other Object
- Formations & Positioning
- Logistics
- Intelligence
- Doctrine



Basic Scenario Entities

- Forces/Population Centers
- Units/Civil Groups
- Equipment
  - Characteristics
  - Interactions
  - Performance

Deployment

- *Origin*
- *Port of Embarkation*
- *Port of Debarkation*

Behaviors/Soft Factors

- *Training Level*
- *Country Of Origin/Side Changing*
- *Morale/Cohesion/Level of Commitment*
- *Degradation of Unit*

Federation "Hooks" (as req'd)

- HLA Certified/DIS capable
  - JSAF Demonstrated
  - Air Defense Demonstrated

JAS Scenario Levels of Effort

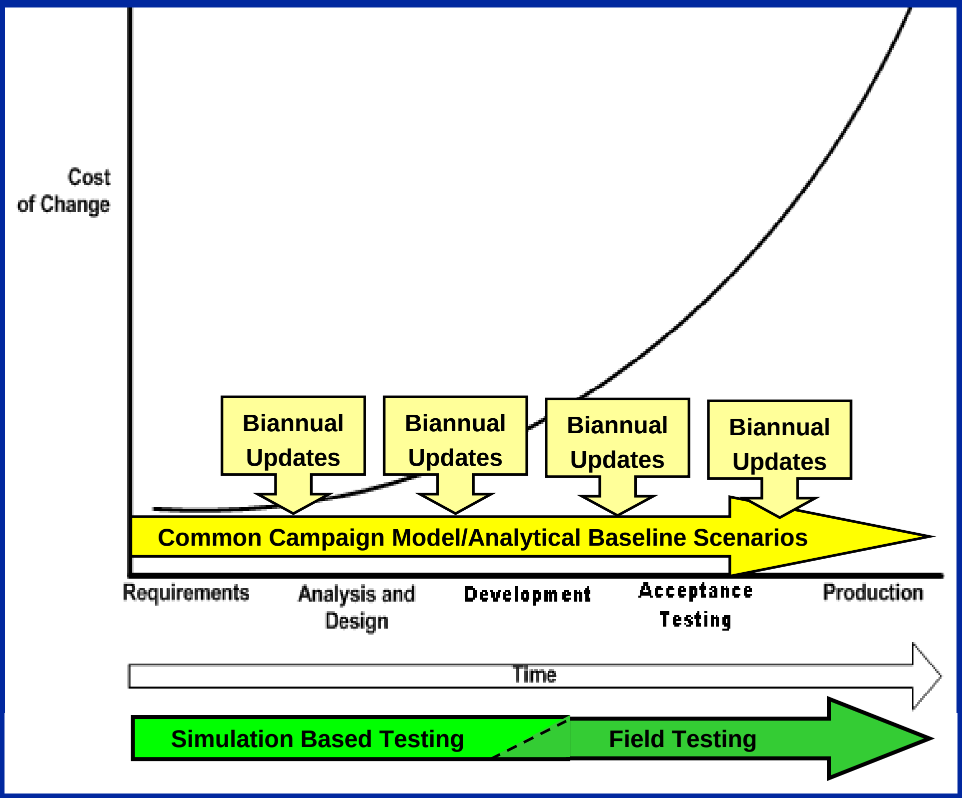
Balanced Joint Domains
Air
Maritime
Land
SOF
Space
with
Communications
ISR
Logistics

- Large Analytical Baseline Scenarios builds are data intensive and require ~ 9 persons 6 months to build whether in a set of legacy models or in JAS
- However, excursions are quick using existing JAS scenarios
- Reusing an existing scenario to conduct studies and evaluate plans requires much less effort
- The concept is to maintain the major scenarios in a status where they can be provided in executable format to any interested (and approved) user

Why Test in a Complex Environment

- **T&E Community can quickly perform rigorous constructive simulations with known data sets**
  - **Enables an "Apples to Apples" comparison**
  - **JAS covers a wide range of realistic, cross-functional scenarios**
- **Provides the ability to Test, Remodel, and Retest Prior to first LRIP in a credible analytic scenario**
  - **Cuts production *and* pre-production costs**
  - **Allows the T&E Community to identify flaws early**
    - » Recommend vital changes to design, and rerun the simulation
- **Offers opportunity to apply early test results to the original National Planning Scenarios**
  - **Assess operational implications of shortfalls or expanded capabilities**

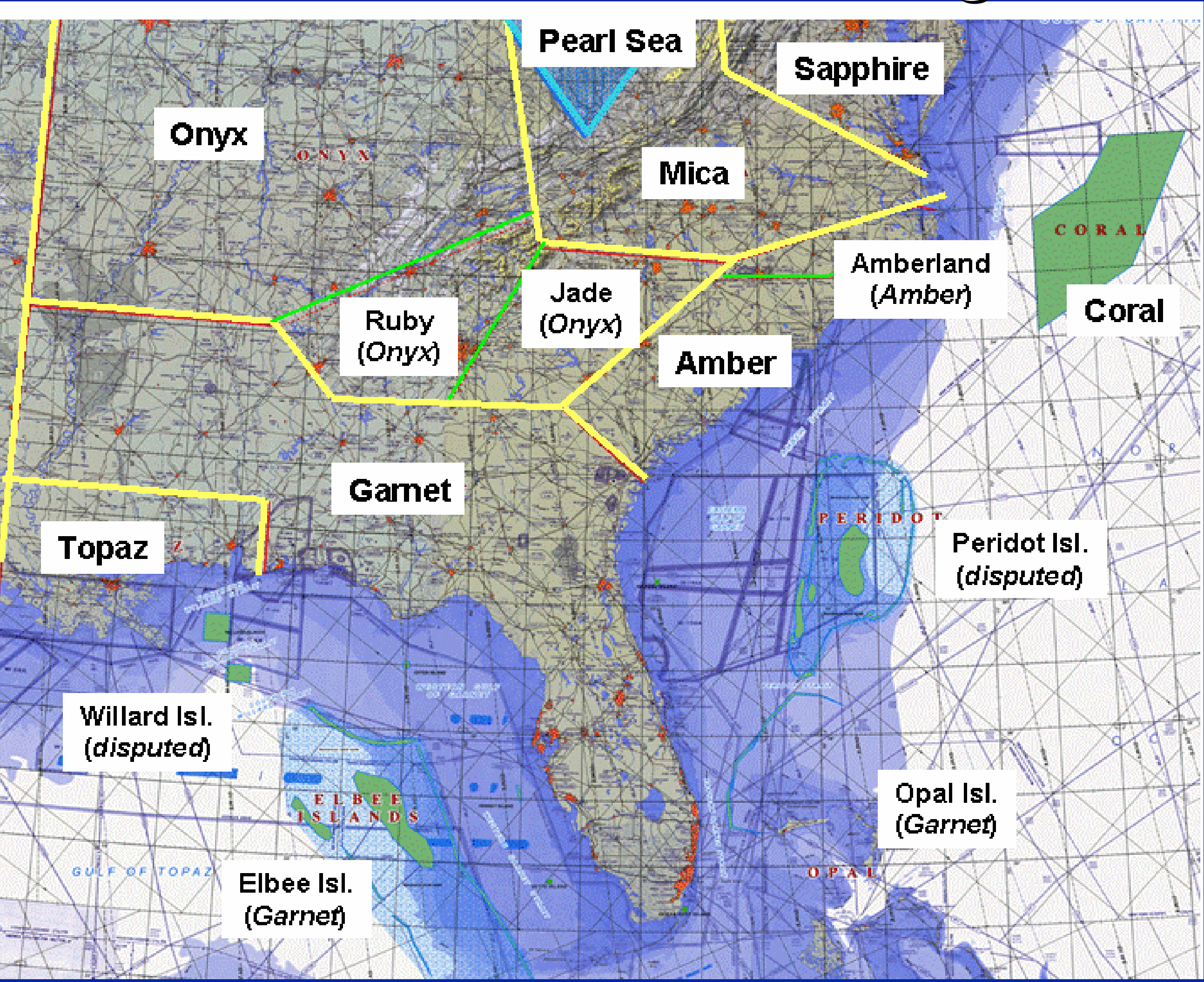
Cost of Change



- Cost of change rises exponentially with time
- JAS provides ability to efficiently model the system under test during Analysis & Design phase
  - Lowers the cost of change
  - Increases the likelihood of successful acceptance test
- Enables engineering community to create best of breed solutions

LOCKHEED MARTIN

Regional Geography Used in the Trident Warrior Wargames

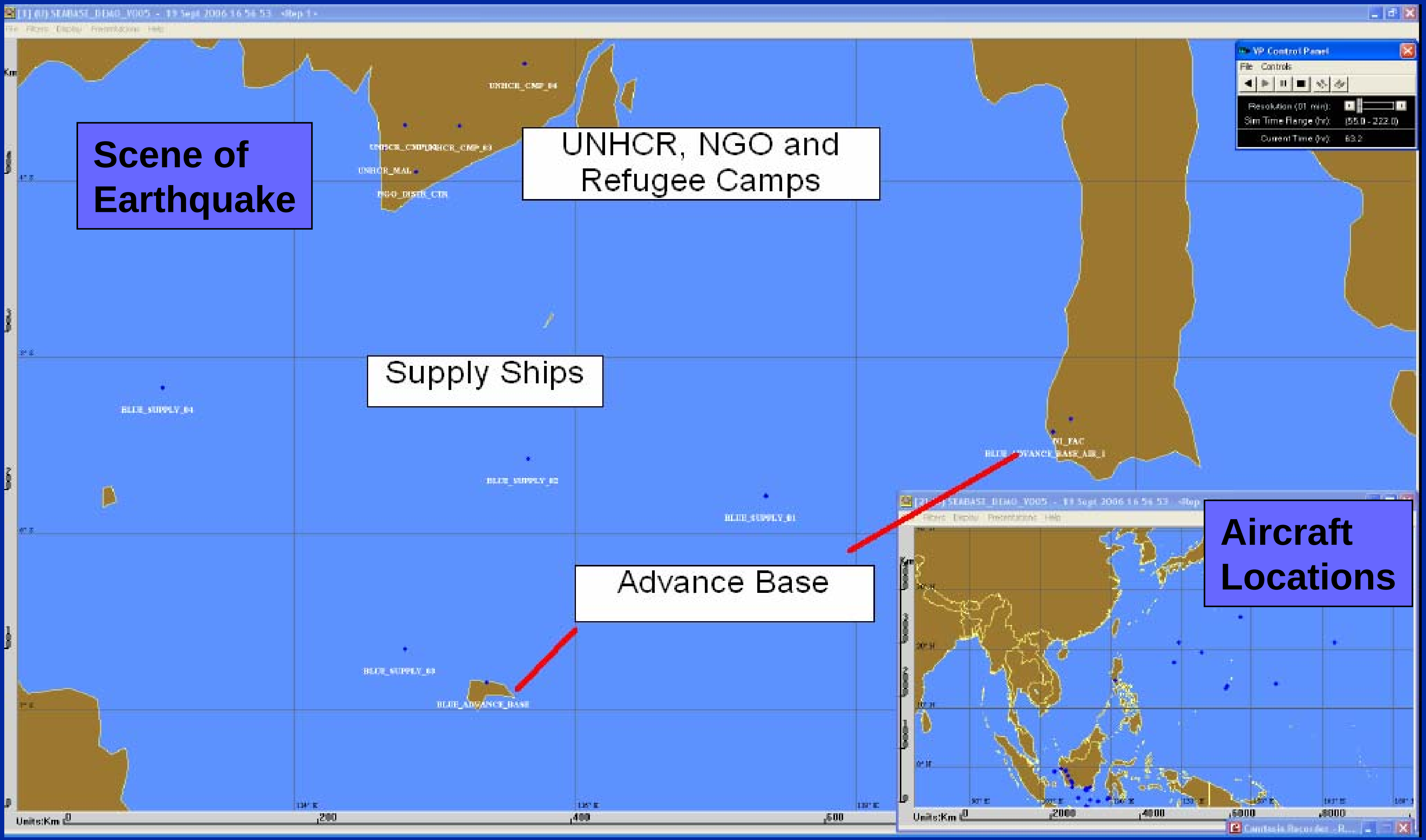


- Multiple sides,
- Countries and non-state BSEs can change sides,
- Considerable coordination and communication of military and civilian law enforcement

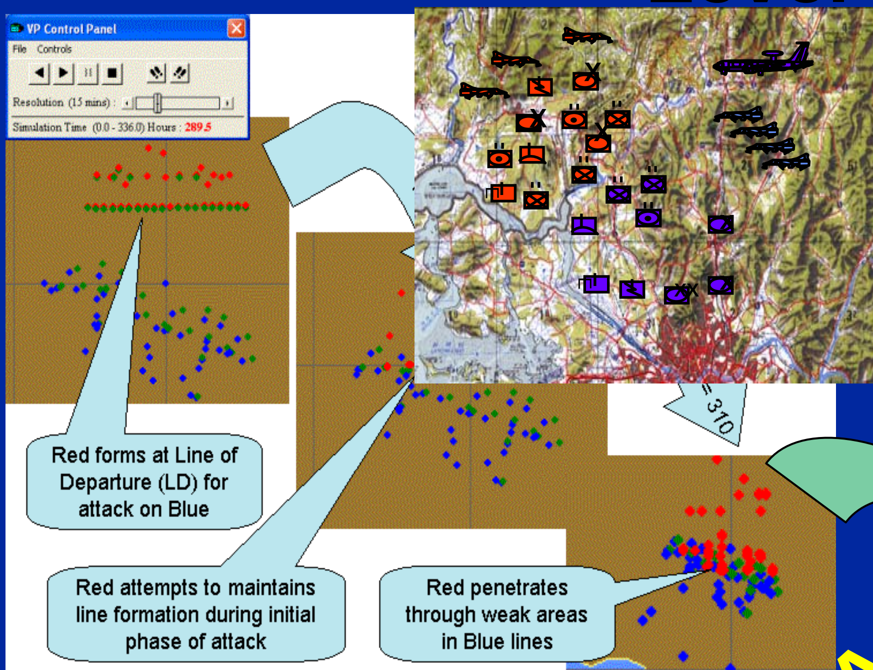
<u>Illustrative Findings</u>

- Initial level of Alert critical to outcome
- Most plans do not address an adaptive opponent

Humanitarian Support Scenario



JAS Can Federate with Mission-Level Models



JAS

- Campaign-level
- Aggregate units
- Measures of Effectiveness

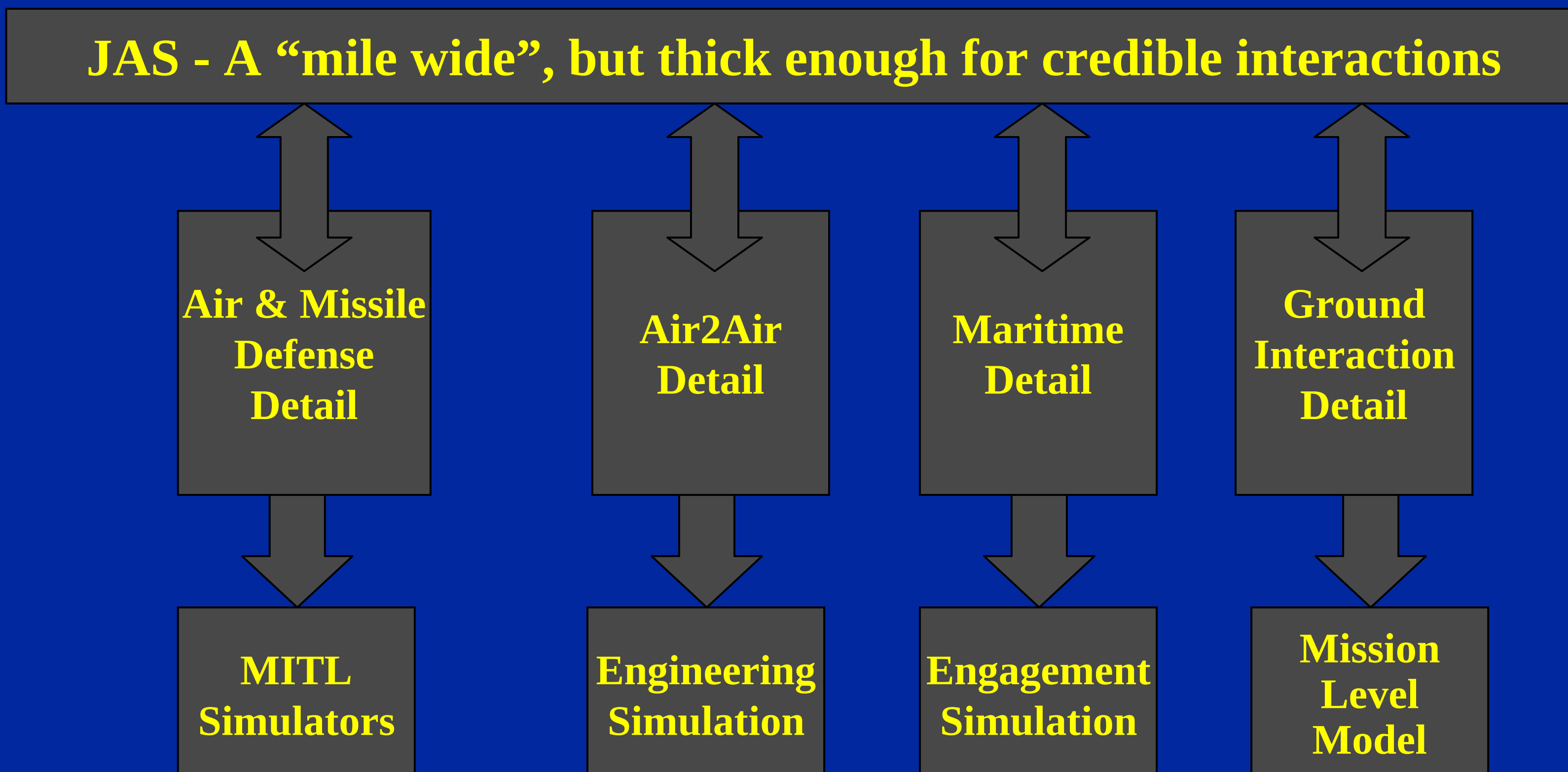
HLA Federation

JSAF

- Mission, in a Campaign context
- Views of Individual Platforms
- Measures of Performance

JAS as a Test Context Generator

- Covers the full breadth of the Theater and its external support elements
- Uses executable scenarios from the Analytical Baseline for credibility



Federating with various models involves some effort, but once completed, other users can employ the same interface

Summary

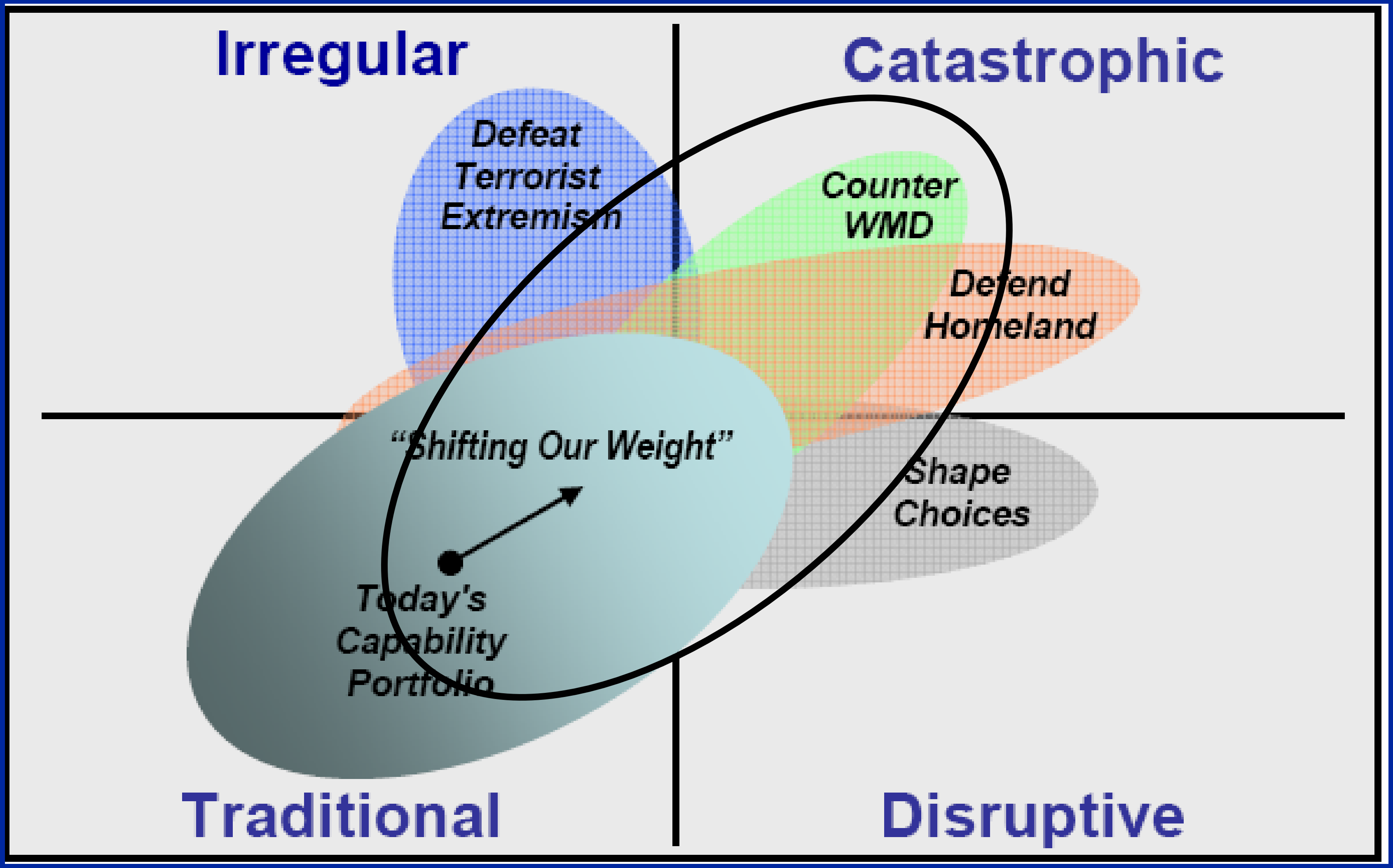
- The T&E Community has the opportunity to participate in using a common analytical simulation framework and scenario context to potentially unify the basis of requirements generation, acquisition, and testing. This automatically links early test simulation effort to the Defense Planning Scenarios and the OSD Analytic Baselines
- JAS is executable GFE software and comes populated with data and scenarios (currently 10 available)
  - While scenario development from scratch is hard, excursions from existing scenarios are relatively easy to run. A mix of both Analytical Baseline (MCO-1 and MCO-2) and Title 10 scenarios are available for immediate execution and instant credibility with minimum effort. Focus can be on the proposed tests and evaluation, not on building scenarios.
  - Cost of ownership is low. Replications generally run on PCs in the Windows, Unix, or Linux operating system. The larger, more complex scenarios require considerable data storage and servers to capture all the output.
  - HLA federation capability allows straight-forward access to more detailed models and human-in-the-loop simulators that can represent proposed systems to be tested in high detail in a full theater context.

BACK-UP

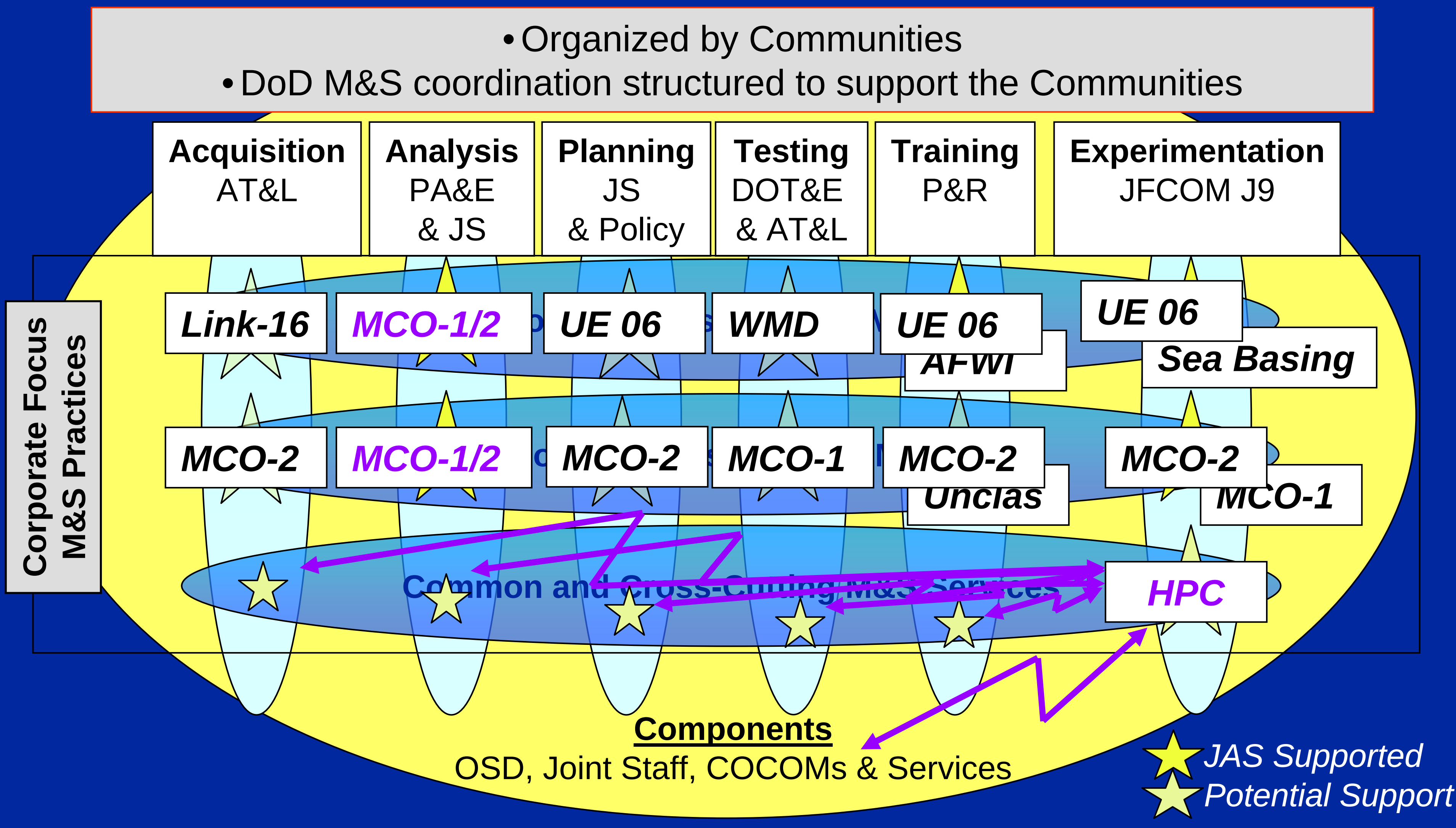
What are the Products of an Analytical Baseline?

- Scenario description
- Concept of Operations (CONOPS)
- Joint, Service, and Threat Data
- Initial assumptions, methodology, analytical results, insights, and challenges
- Documentation, usually in paper or electronic format
- With the addition of JAS to the family of analytical models, an analysis can also produce an executable and maintainable simulation of the specific Scenario, Plan, or Exercise of interest. This can form the basis for further studies or excursions using the same validated scenario.
  - Over a dozen major scenarios are either completed as the basis for analytical baselines or are in development.
  - Three of these MCO’s have been translated into JAS.

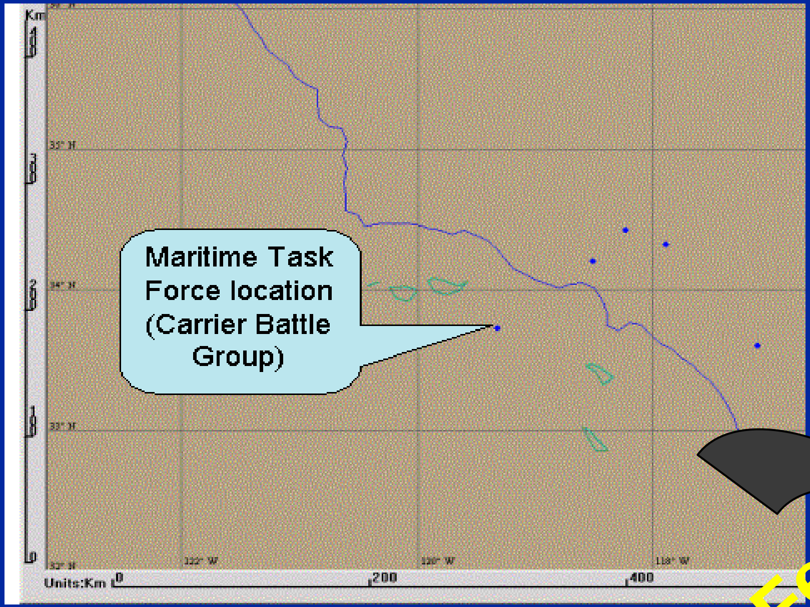
Analytic Agenda Future



DoD M&S Framework and JAS



Maritime HLA Example from a Common Scenario



JAS Aggregated Campaign Level

- Combatant locations and interactions
- C4ISR interactions
- Weather/Sea Conditions

HLA Federation

JSAF Disaggregated Mission Level Representation

An Enterprise Environment for Information Assurance / Computer Network Defense Testing and Evaluation

Parker Horner, EWA Gov't Systems Inc.

Steve Moore, Booz|Allen|Hamilton

Today's Agenda

- Introduction
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder "views"
- Approach and Risks
- Summary

Today's Agenda

- ***Introduction***
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder "views"
- Approach and Risks
- Summary

Our Thought

- IA-CND testing needs an enterprise solution
- Network enabled operations the norm and growing more robust (by the day)
  - Multiple Mission threads
- How to test IA/CND in a realistic Mission or “Enterprise” environment???
  - Mission Thread equipment and manpower fully committed

We’ll explore the idea of using the IO Range as a launching point for a DOD enterprise environment for IA/CND testing

Today's Agenda

- Introduction
- ***Background***
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder "views"
- Approach and Risks
- Summary

Underpinnings

- Definitional and Doctrinal Discussion
  - IA, CNO, CNE, CNA, CND
  - **Information Assurance —**availability, integrity, authentication, confidentiality, and non-repudiation … restoration … protection, detection, and reaction capabilities. Note: CND provides operational direction and guidance through global network operations and defense for employment of IA in response to a CND alert or specific threats.
  - **Computer Network Operations** — Comprise CNA, CND, and related CNE enabling operations
  - **Computer Network Exploitation** (CNE) — Enabling operations and intelligence collection… adversary automated information systems or networks
  - **Computer Network Attack**— disrupt, deny, degrade, or destroy information …computers and networks themselves
  - **Computer Network Defense** — protect, monitor, analyze, detect, and respond to unauthorized activity within DoD information systems and computer networks …employs IA capabilities to respond to unauthorized activity …employs intelligence, counterintelligence, law enforcement, and other military capabilities to defend DoD information and computer networks

(DoDD O-3600.01, Information Operations, August 14, 2006)

Today's Agenda

- Introduction
- Background
  - Definitions, Doctrine
- ***Policy and Direction***
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder "views"
- Approach and Risks
- Summary

Policy and Direction

- Congress and the 2003 Appropriations Act (the IA wake-up call for Joint Exercises)
- DOT&E in Nov 2006 – IA OT&E policy
  - End to End, all major and supporting systems
- USD(AT&L) and DOT&E in Dec 2007 – operational and mission context
  - Mission environment, Projected threat, Life cycle

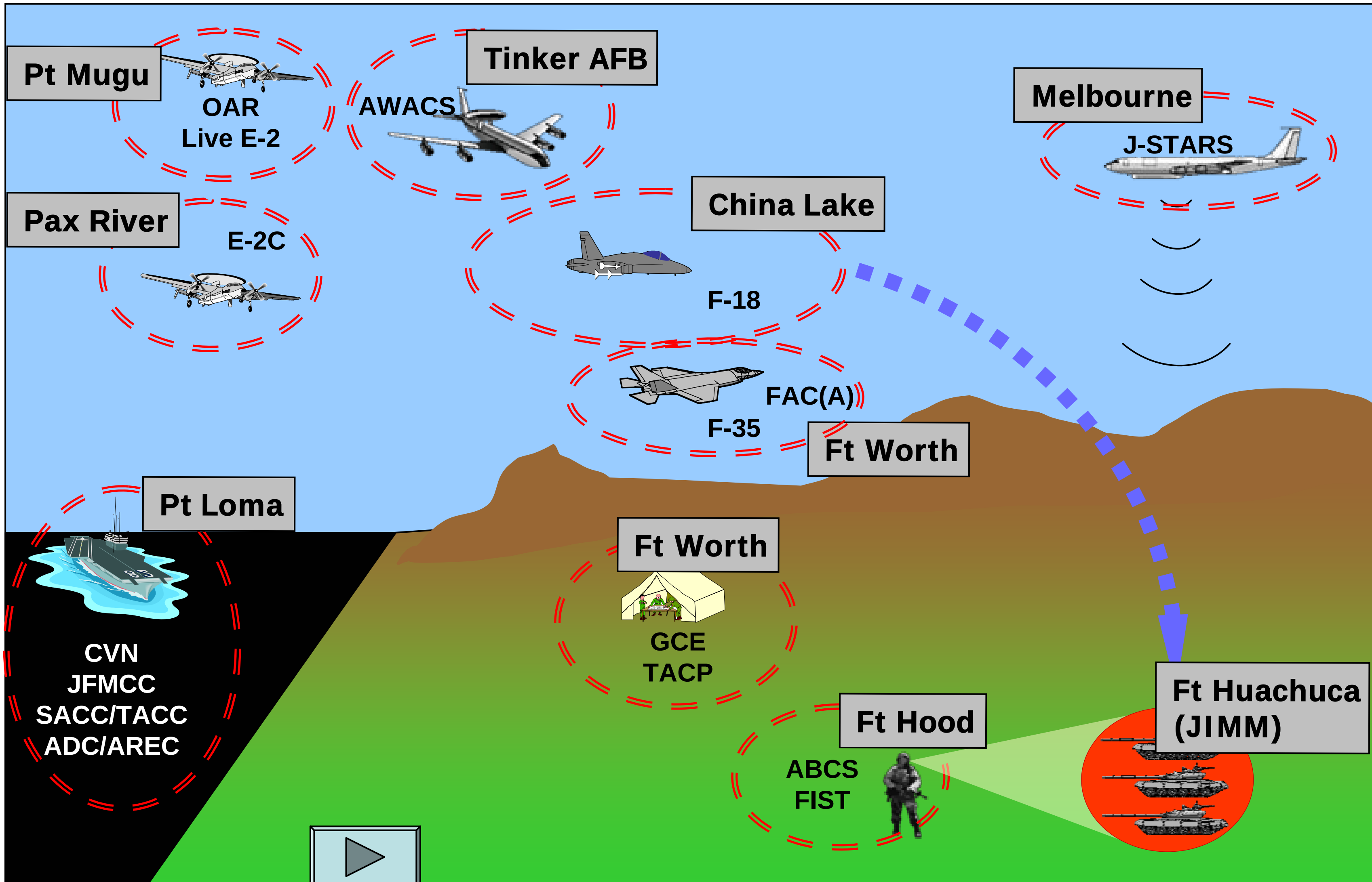
Today’s Agenda

- Introduction
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- ***Creating the Joint Operational Environment (and the Challenges)***
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder “views”
- Approach and Risks
- Summary

Joint Operational Environment

- What is in it
  - Platforms, C2, Data Links, ISR, Data management
- How to create it
  - Live assets very limited
  - Virtual, constructive not geographically collocated
- The implied challenges
  - Realistic operation, interaction of elements
  - Bring the environment to the SUT
- Persistence?
  - Ready in hours, not weeks
  - Available for “test, fix, re-test” cycling
  - Consistent, Knowledgeable

JCAS example



Today's Agenda

- Introduction
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- ***DoD IO Range***
  - Background, Current Focus, Vision
- Stakeholder "views"
- Approach and Risks
- Summary

DoD IO Range

- DoD IO Roadmap of 2003
- Nov 2005 DepSecDef decision
- July 06 IOC for CNA test support
- Range Architecture
- Current Focus of IO Range
- The Vision for the IO Range
  - Full Spectrum IO
    - Implied Mandate for IA/CND
  - Bringing confidence to Joint Force Commanders
- Acquisition Program Requirements
  - Need growing
  - Require dependable, repeatable, expertise

What role should the IO Range play in DOD IA/CND testing?

Today’s Agenda

- Introduction
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- ***Stakeholder “views”***
- Approach and Risks
- Summary

Stakeholders

- USD(I), ASD/NII
  - IA/CND must be delivered to warfighter, not fixed in the field
- DOT&E
  - Test like we fight, Realism, Mission/Threat representative
- JS J5, J3, J6
  - Want COCOM confidence in IO, IA, CNO
- USD (P&R)
  - Consistency between testing and training environment, CONOPS, TTPs
- STRATCOM
  - IO Warfighter Support Teams must be part of Mission Thread, CONOPS, TTP definition process
- JFCOM
  - "Service Provider" for Joint Test and Training needs
  - Consistency a must!!

Today's Agenda

- Introduction
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder "views"
- ***Approach and Risks***
- Summary

Approach and Risks

- Cannot step-function jump into IA/CND
- Pilot or Proof-of-concept required
- Leverage successes of IO Range
  - Handling multiple levels of classification
  - Identify what changes are needed for IA/CND
- Rate of pace of change and stresses that places on IA/CND
  - 75 + potential “IA/CND” acquisition Programs in the FY08, 09, 10 alone
  - What mission threads?
- Is there enough SME to support the IA/CND workload?

Today’s Agenda

- Introduction
- Background
  - Definitions, Doctrine
- Policy and Direction
  - Congress, DoD (DOT&E, AT&L)
- Creating the Joint Operational Environment (and the Challenges)
- DoD IO Range
  - Background, Current Focus, Vision
- Stakeholder “views”
- Approach and Risks
- ***Summary***

Summary

- Framed a potential DOD-wide solution starting point for IA/CND testing
- Need to build to workload and confidence levels
- IO Range – “Provider of Choice”
- Look to continue the dialogue

GENERAL DYNAMICS
Land Systems

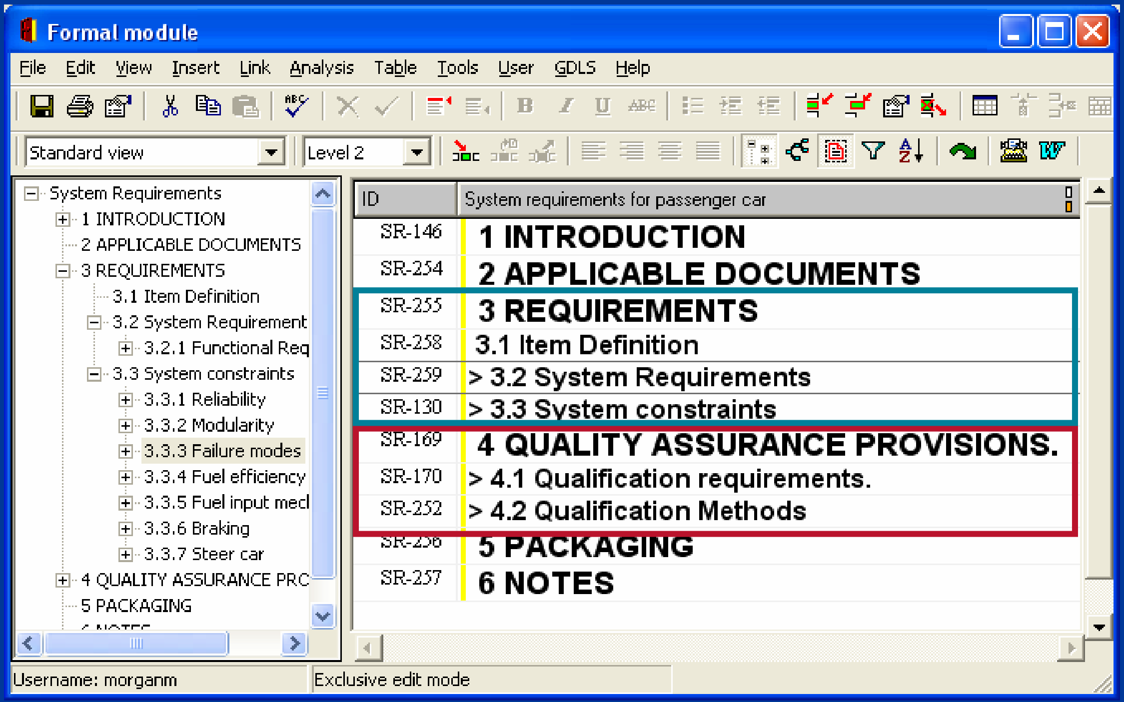
Automatic generation of Requirement Specifications (Verification Section) – in DOORS

Monika Morgan
Feb 08, 2008

morganm@gdls.com

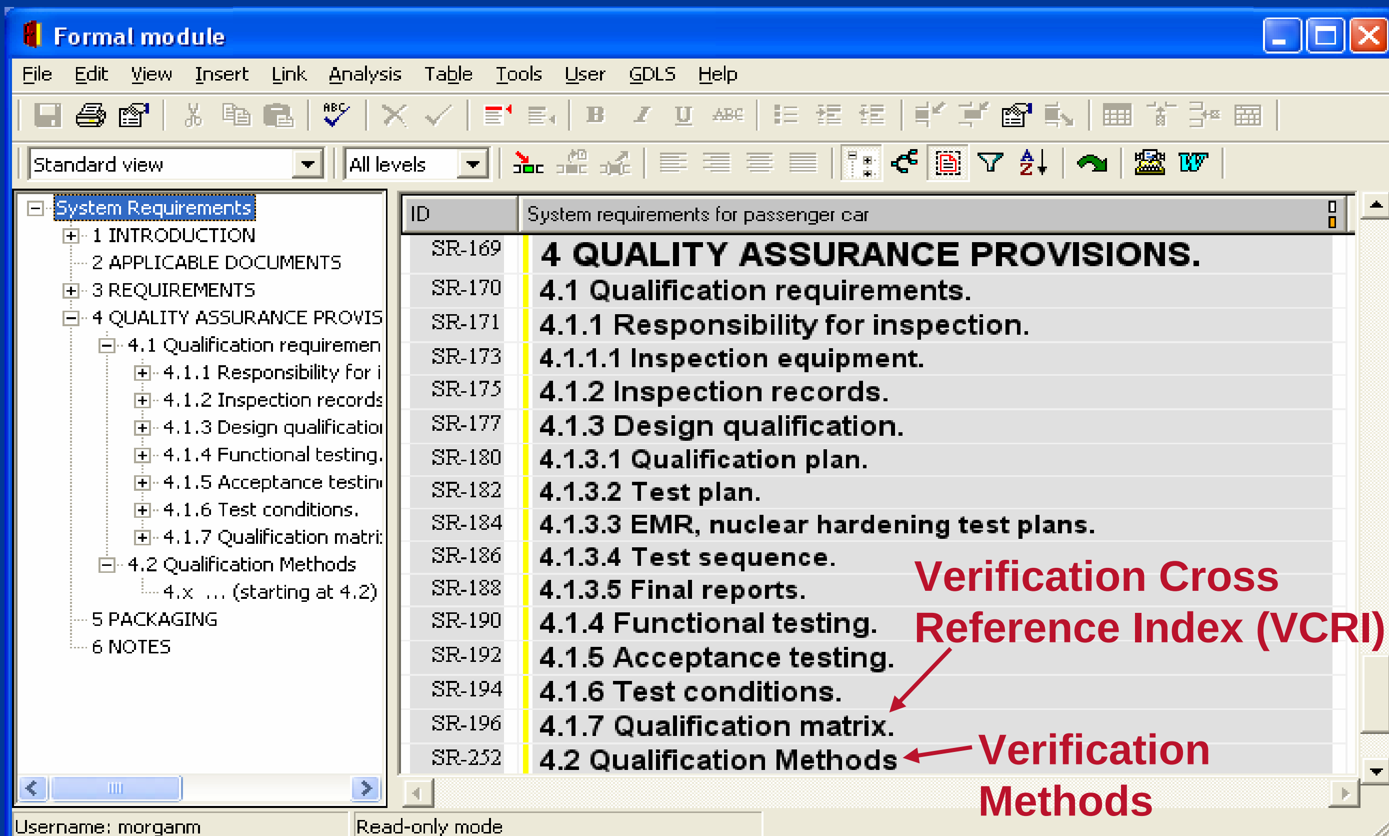
Requirement Specifications

- Department of Defense requirement specifications are primarily composed of six sections (per MIL-STD-961D), including one for Requirements (Section 3) and another for Quality Assurance Provisions (aka Verification) (Section 4).



Verification Section (4.0)

- The Verification Section is composed of:



Verification Section – VCRI Matrix Template

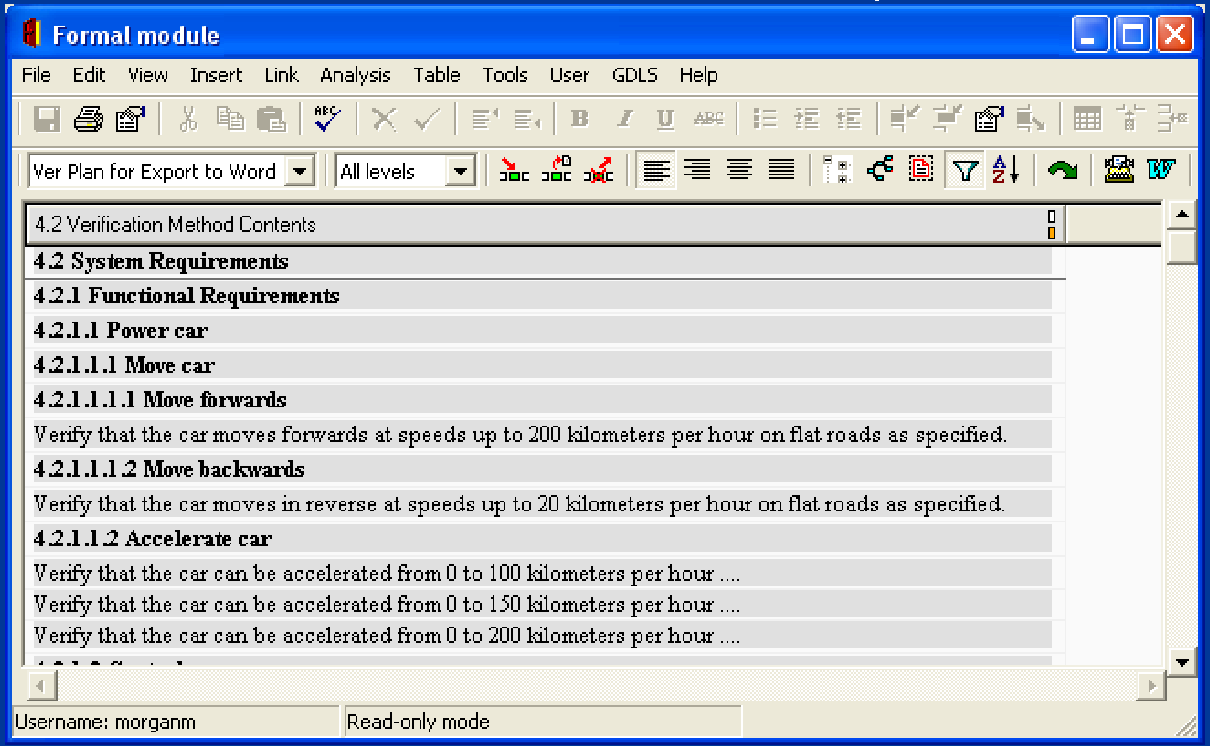
- Within this table, the outline for Section 3 is repeated in “Section 3 Par.”
- “Section 4 Par” (Qualification Methods) paragraph numbering is very similar, usually only replacing the “3.” with “4.”.

Verification Legend		Method N/A Not Applicable A Analysis I Inspection D Demonstration T Test					
		Method					
Section 3 Par	Requirement Title	N/A	A	I	D	T	Section 4 par

morganm@gdls.com

Verification Section – Verification Methods

- Each object is covered by a plan for testing the requirement
- It may be written with a “Shall” as a test requirement.
- Structure of this section follows structure for Requirement Section (3.0)



The Problem

- In the past, these documents were generated manually, initially using typewriters and more recently word-processor software.
  - Creating and maintaining the VCRI matrix using available table functions can be very cumbersome.
  - Since the VCRI table and the Verification Method section are both organized to match the structure of Section 3, their contents will be affected by any changes in structure to the requirements.
  - Some Engineers claim that the requirements and section structure are stable once populating Section 4. However, the maintenance is still required and can be very tedious when changes do occur.
  - Even when using a requirements management tool like DOORS®, a user may be tempted to directly populate their VCRI and Verification Method sections directly in Section 4.

DOORS For Specifications

- Many corporations now require requirements to be captured into some kind of database, which allows the capability to show traceability to customer requirements.
- Our company has chosen Telelogic's DOORS®, which also allows requirements to be organized to resemble the document being published.
- The skeleton for the document is organized per specific document standards and generally a template module is created to contain the basic structure and a standardized set of attributes and views to the data.
- The template is then used for creating new modules.

Key Verification Attributes

- The "Verification Method" attribute has enumerated values to allow the user to indicate how a requirement would be verified. These values may include:
  - N/A (used for non-requirement objects, including headers)
  - Analysis
  - Inspection
  - Demonstration
  - Test
- If the attribute is set up as a multi-pick, the user should make the best single pick (there may be certain situations where two values are appropriate, but this is the exception).

Key Verification Attributes – Cont'd

- The "Verification Plan" attribute is intended to contain a sentence or two on how the requirement is to be tested and may be written as a test requirement. This attribute is not intended for major detailed plans, as this detailed information would be handled in a separate Verification Plan document.
- Tables or Figures in section 3 can be referenced

Key Verification Attributes – Cont'd

- Tables or Figures that are unique for testing can be included directly in Section 4.2.
- Besides indicating how each requirement will be tested, establishing values for both of these attributes also helps to isolate/correct requirements that may have not been written well (i.e. not testable).

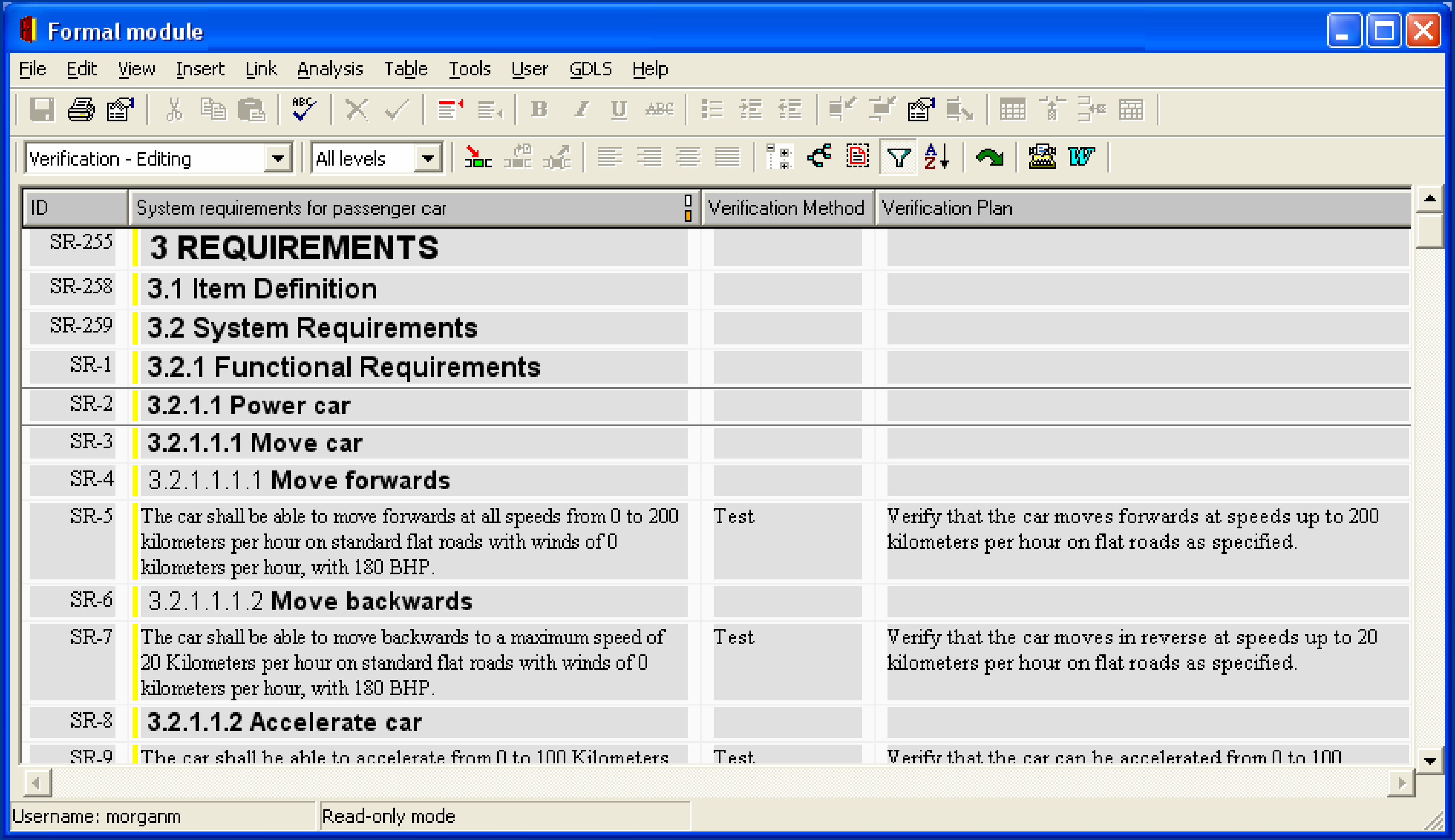
Key Verification Views

- Three specific views have been created to facilitate editing and reporting the values of these attributes.
  - "Verification – Editing"
  - "VCRI for export to MS Word"
  - "Ver Plan for export to MS Word"
- These 3 views provide the basic layout and a simple filter. Specific filters can be created when exporting limited requirements for a specification.

Key Views – Editing Attributes

- The "Verification – Editing" view was created to allow the user to populate verification related attributes for each of the requirements.
- Generally, it is filtered to display all the requirements in section 3, their ancestor parents and the key verification attributes listed above.
- Other verification type attributes that will be used for testing down the line may also be included in this view (status, comments, etc.)

Key Views – Editing Attributes, Cont’d



ID	System requirements for passenger car	Verification Method	Verification Plan
SR-255	3 REQUIREMENTS		
SR-258	3.1 Item Definition		
SR-259	3.2 System Requirements		
SR-1	3.2.1 Functional Requirements		
SR-2	3.2.1.1 Power car		
SR-3	3.2.1.1.1 Move car		
SR-4	3.2.1.1.1.1 **Move forwards**		
SR-5	The car shall be able to move forwards at all speeds from 0 to 200 kilometers per hour on standard flat roads with winds of 0 kilometers per hour, with 180 BHP.	Test	Verify that the car moves forwards at speeds up to 200 kilometers per hour on flat roads as specified.
SR-6	3.2.1.1.1.2 **Move backwards**		
SR-7	The car shall be able to move backwards to a maximum speed of 20 Kilometers per hour on standard flat roads with winds of 0 kilometers per hour, with 180 BHP.	Test	Verify that the car moves in reverse at speeds up to 20 kilometers per hour on flat roads as specified.
SR-8	3.2.1.1.2 Accelerate car		
SR-9	The car shall be able to accelerate from 0 to 100 Kilometers	Test	Verify that the car can be accelerated from 0 to 100

Key Views – VCRI Matrix

- The “VCRI for export to MS Word” view is prepared to look like the intended VCRI matrix.
- Individual columns display an “X” for each of the enumerated values of the “Verification Method” attribute. This is handled by DXL layout code. While this code can be very simple and included in each column, a customized script was written that provides the following:
  - Ability for the designer to pass the attribute name and enumerated value (set up for multi-pick enumerated attributes).
  - Verification that the provided attribute name exists and if not, displays an error directly in the layout column. This error message is for the designer’s sake and is not intended for receipt by a user.
  - Automatic classification of Header Objects as "N/A“.

Key Views – VCRI Matrix, Cont'd

- The "Section 4 Par" column displays the paragraph structure for Section 4.2, which corresponds directly with the Section 3 paragraph structure.
- This view is exported to Microsoft Word (MS Word) as a table in a separate document and then is added to the VCRI template (as seen earlier) via a copy/paste.

Key Views – VCRI Matrix, Cont'd

Formal module

File Edit View Insert Link Analysis Table Tools User GDLS Help

VCRI For Export to Word | All levels

Requirement Paragra	Title	N/A	A	I	D	T	Section 4 Paragraph
3.2.1.1	Power car	X					4.2.1.1
3.2.1.1.1	Move car	X					4.2.1.1.1
3.2.1.1.1.1	Move forwards	X					4.2.1.1.1.1
3.2.1.1.1.1.0-1	Move forwards					X	4.2.1.1.1.1.0-1
3.2.1.1.1.2	Move backwards	X					4.2.1.1.1.2
3.2.1.1.1.2.0-1	Move backwards					X	4.2.1.1.1.2.0-1
3.2.1.1.2	Accelerate car	X					4.2.1.1.2
3.2.1.1.2.0-1	Accelerate car					X	4.2.1.1.2.0-1
3.2.1.1.2.0-2	Accelerate car					X	4.2.1.1.2.0-2
3.2.1.1.2.0-3	Accelerate car					X	4.2.1.1.2.0-3
3.2.1.2	Control car	X					4.2.1.2
3.2.1.2.1	Switch on car	X					4.2.1.2.1
3.2.1.2.1.0-1	Switch on car				X		4.2.1.2.1.0-1
3.2.1.2.2	Control speed	X					4.2.1.2.2
3.2.1.2.2.0-1	Control speed			X			4.2.1.2.2.0-1
3.2.1.2.2.0-2	Control speed			X			4.2.1.2.2.0-2
3.2.1.2.2.0-3	Control speed				X		4.2.1.2.2.0-3

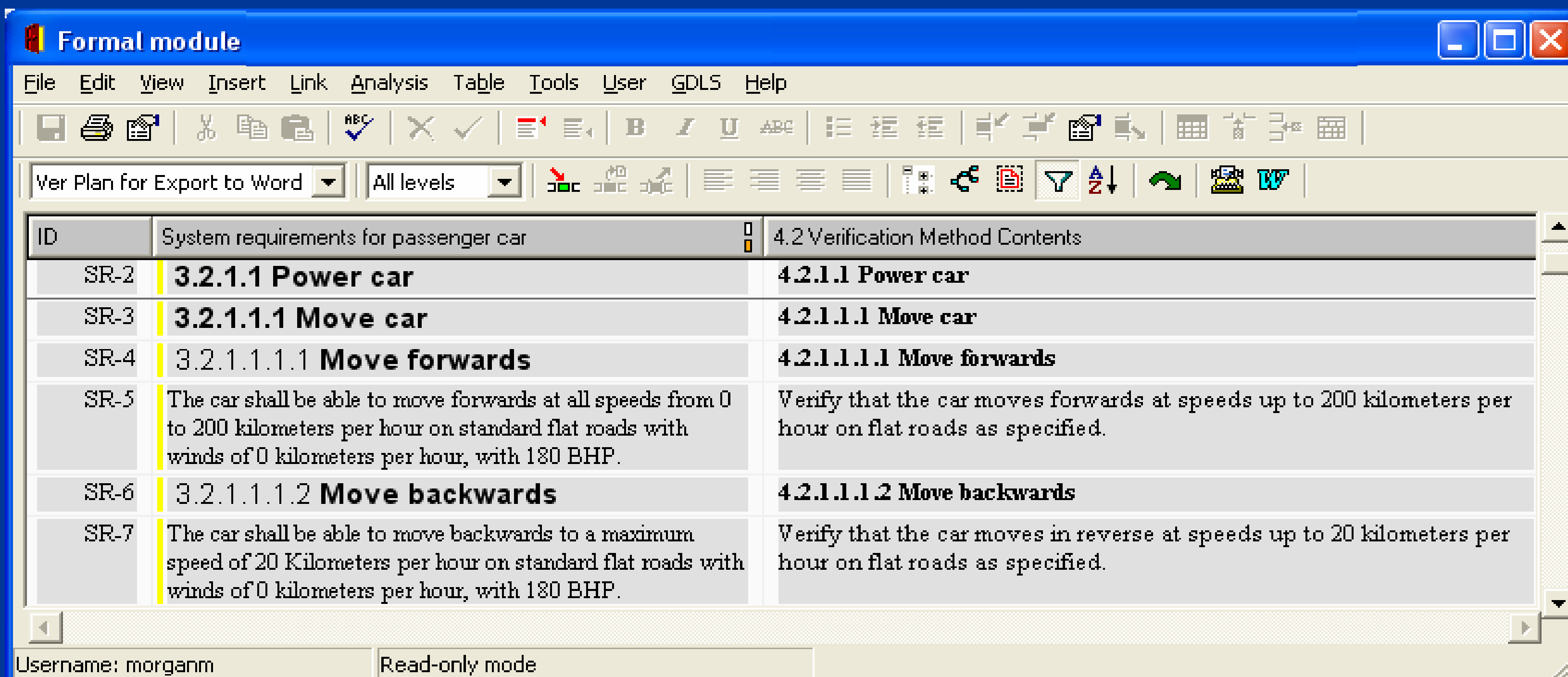
Username: morganm | Read-only mode

Key Views – Verification Plan

- The “Ver Plan for export to MS Word” view is prepared to look like section 3, showing all headers and text, but the text in this case displays the contents of the “Verification Plan” attribute.
  - This view can be setup to display all objects that have a value in this attribute, while skipping those that do not, and can include figures, tables and their captions.
    - The capability to display figures/captions recognizes that while figures in section 3 may be referenced, some cases require special values in the tables or figures.

Key Views – Verification Plan, Cont’d

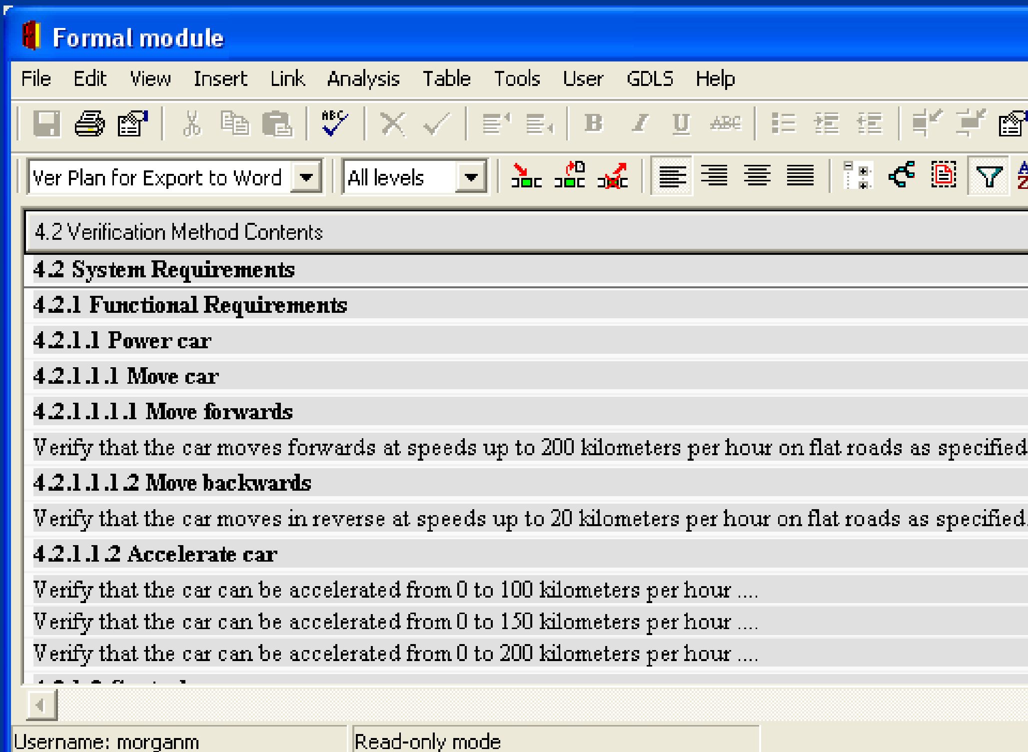
- While this view displays 3 columns, the ID and requirement columns are provided for context and must be removed before exporting the view to Microsoft Word in Book format. The results of the export would be copy/pasted into section 4.2 of the Main Document.

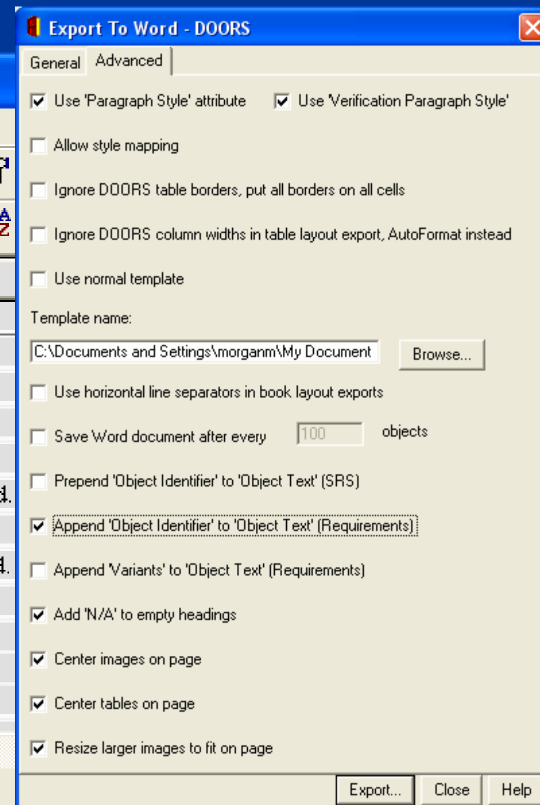


ID	System requirements for passenger car	4.2 Verification Method Contents
SR-2	**3.2.1.1 Power car**	**4.2.1.1 Power car**
SR-3	**3.2.1.1.1 Move car**	**4.2.1.1.1 Move car**
SR-4	3.2.1.1.1.1 **Move forwards**	**4.2.1.1.1.1 Move forwards**
SR-5	The car shall be able to move forwards at all speeds from 0 to 200 kilometers per hour on standard flat roads with winds of 0 kilometers per hour, with 180 BHP.	Verify that the car moves forwards at speeds up to 200 kilometers per hour on flat roads as specified.
SR-6	3.2.1.1.1.2 **Move backwards**	**4.2.1.1.1.2 Move backwards**
SR-7	The car shall be able to move backwards to a maximum speed of 20 Kilometers per hour on standard flat roads with winds of 0 kilometers per hour, with 180 BHP.	Verify that the car moves in reverse at speeds up to 20 kilometers per hour on flat roads as specified.

Key Views – Verification Plan, Cont'd

- The Export to Word function can be extended to display this column with the same styling as the Object Text/Object Heading column, instead of being exported as attributes of Object Text.





Ready for Export

- A specification is handled by 3 separate exports:
  - ➢ Main Document, which includes the contents in Sections 1-6
  - ➢ VCRI Matrix
  - ➢ Verification Plan
- The export can be handled:
  - ➢ Manually - manually merged and polished
  - ➢ Semi-automated - A single script could be developed that performs the exports and merges. Some manual polishing will be required afterwards.

Export Templates

- In preparation for the exports, MS Word template files (.dot files) have been created to direct the exports, provide headers/footers, a cover page, a Table of Contents and style formatting for the whole document. They also provides caption styles for Table and Figure captions.
  - **Document contents and Section 4.2 contents:**
    - Draft Release for the document contents (only for internal reviews)
    - Official Release for the document contents
  - **VCRI Matrix:**
    - Verification Template

Exporting a Specification

Contents	View Name	Export Template	Book/Table
Main Document	CIDS Export to MS Word	Official Release	Book
VCRI	VCRI for export to MS Word	Verification	Table
Verification Plan	Ver Plan for export to MS Word	Official Release	Book (1)
	Ver Plan for export to MS Word	Official Release	Table (2)

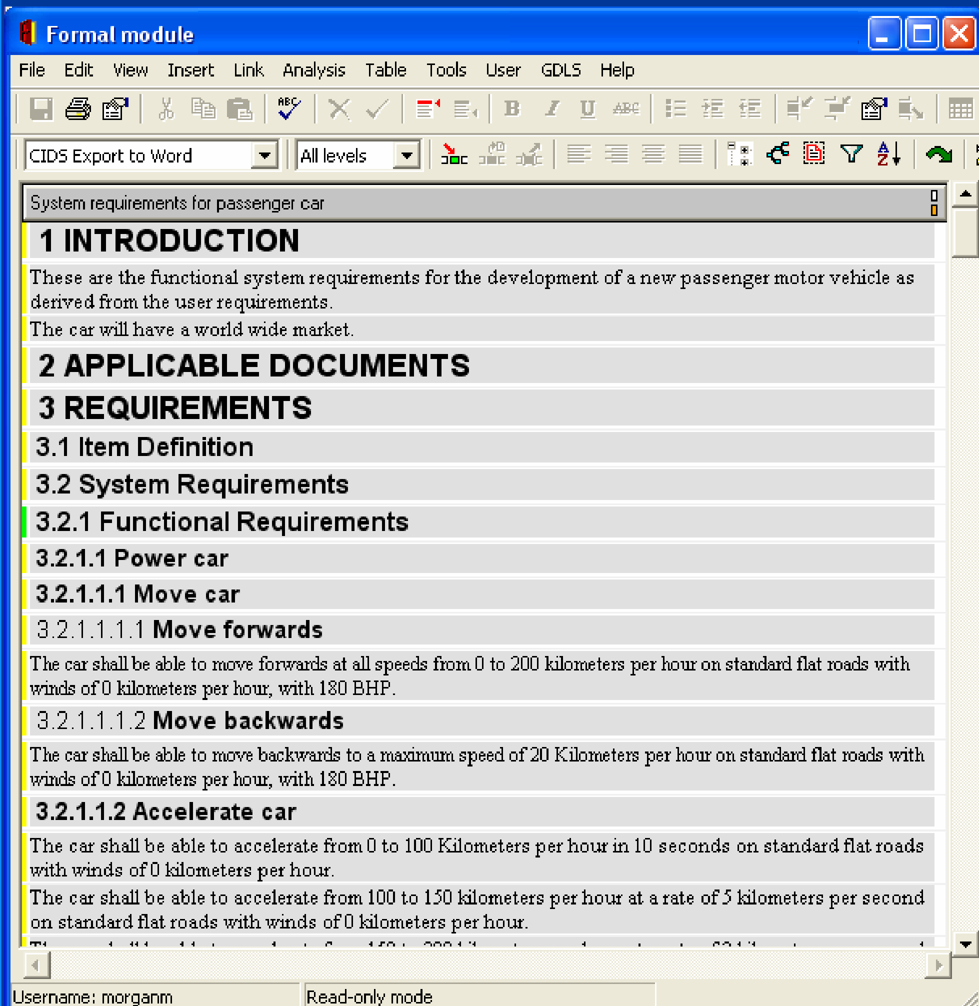
Notes: (1) Verification Plan exported via an extended Export to Word function

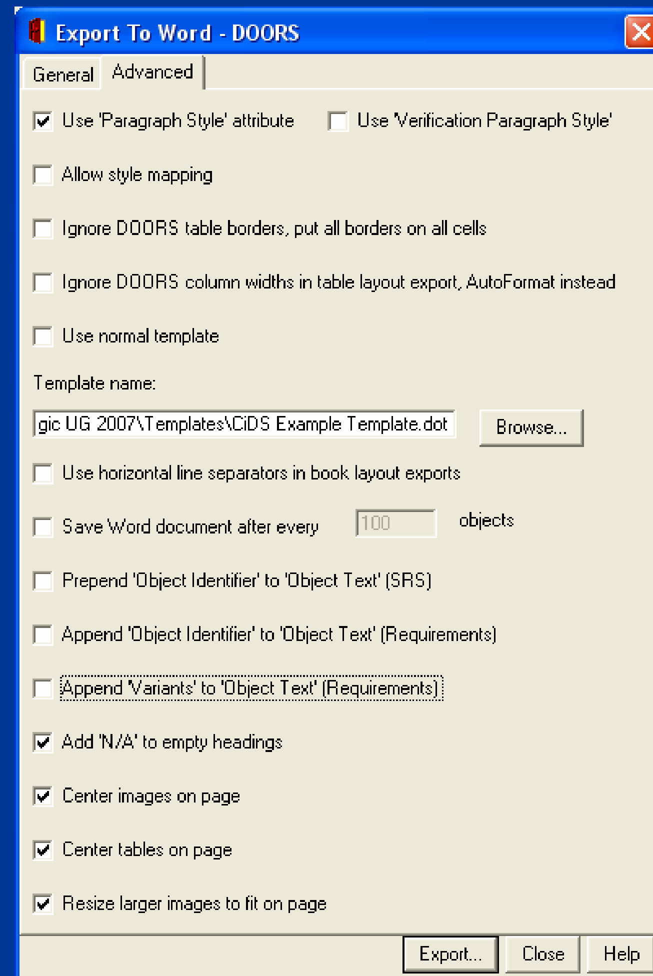
(2) Verification Plan exported via the "Out of the Box" Export to Word function

Exporting the Main Document

- A view, such as “CIDS Export to Word” would include only the main column (Object Text and Object Heading)
- The view can be extended with the desired filter based on allocation attributes, if necessary
- The results of this export will be the working copy towards a completed specification. The VCRI and Verification Plan exports will be merged into this document within Section 4. The resulting MS Word document will be referred to as the “Main Document”.

Exporting the Main Document - View



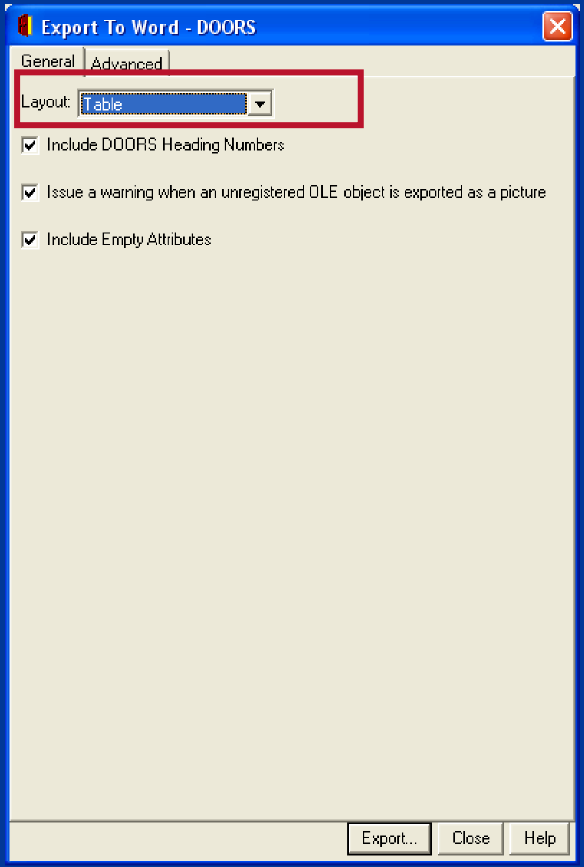


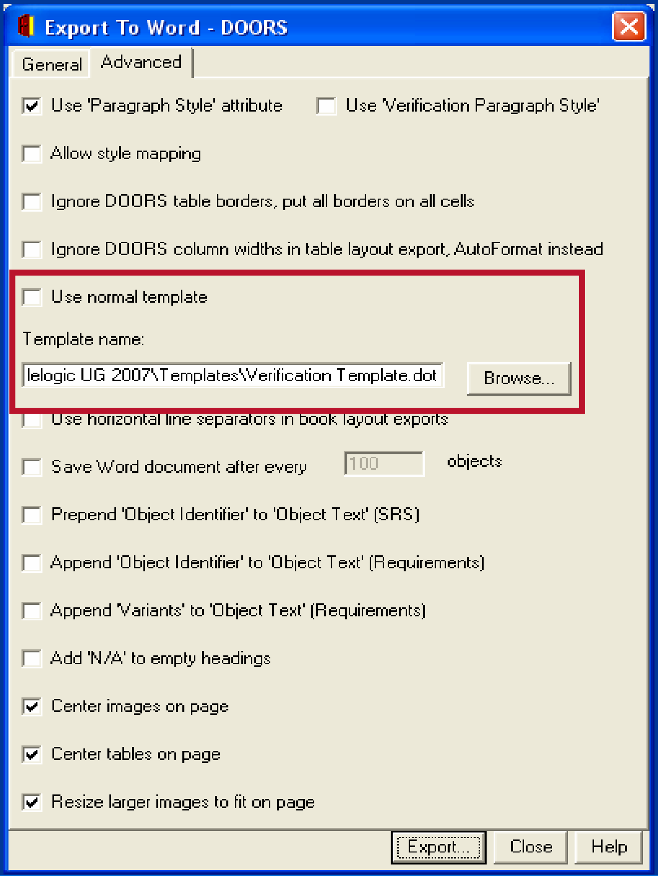
Exporting the VCRI Matrix

- The matrix is supplied via a view like the “VCRI for export to MS Word”, which can be tailored for specific specifications.
- The view is filtered to only show requirements and headers in Section 3, normally starting at 3.2.
- The view is exported as a MS Word Table.
- Selecting to use a specific export template like “Verification Template.dot” will provide an empty VCRI table at the top of the file with desired formatting for columns.

Exporting the VCRI Matrix, Cont'd

- Running the Export to Word function:





Exporting the Verification Plan

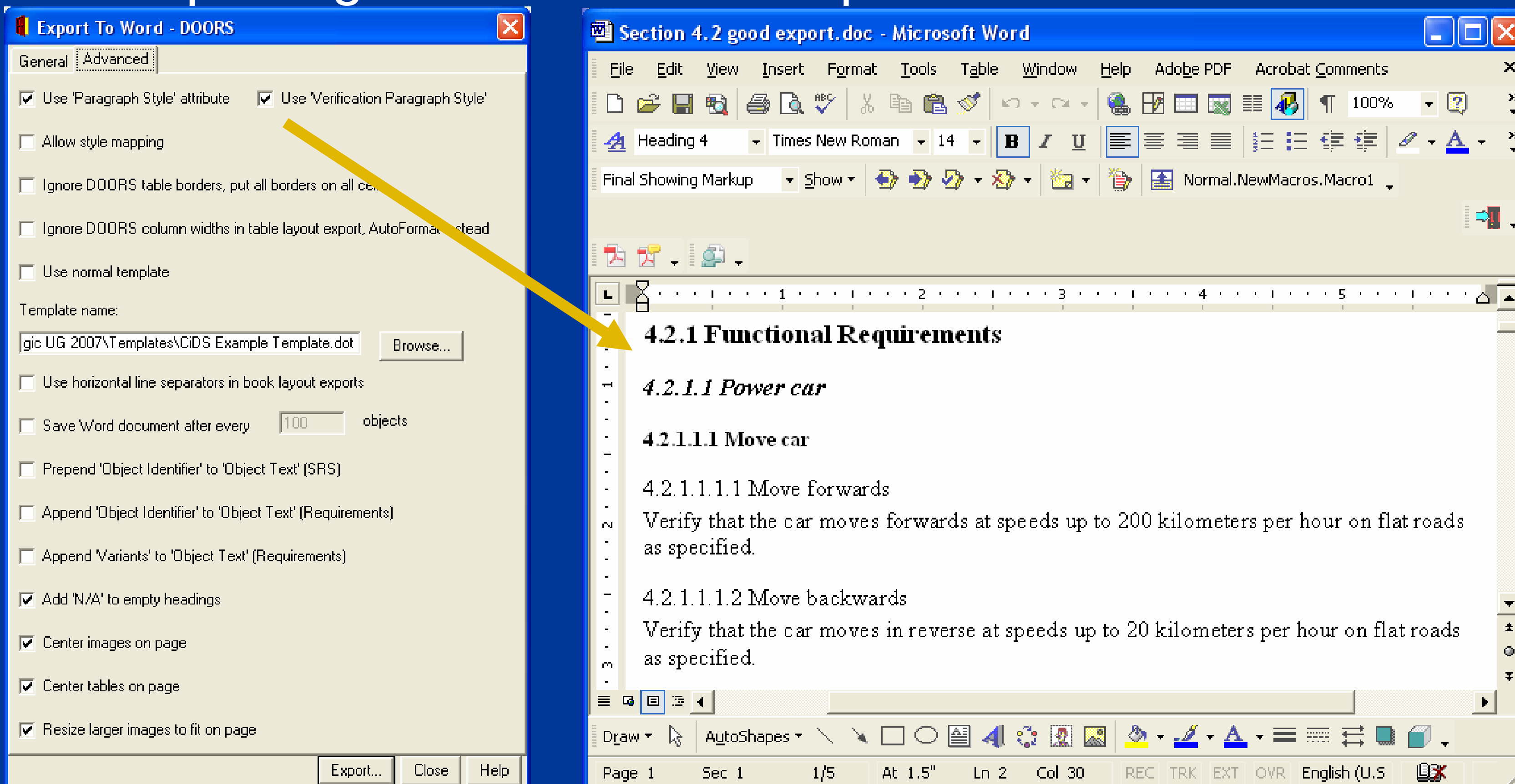
- The Verification Plan contents is supplied via a view like the “Ver Plan for export to MS Word”, which can be tailored for specific specifications.
- The view is filtered to show requirements and headers in Section 3, normally starting at 3.2.
- The Verification Plan export needs some special handling. Exporting in Book format normally leads to undesired effects, listing the column as an attribute for each requirement object.

Exporting the Verification Plan, Cont'd

- The Export to Word script can be extended to export this column as if it were the main column, which would then assign styles to Headers and captions if tables/figures are included.
- The final results of this export are in a new MS Word document and need to be merged in to the Main Document under Section 4.2.

Verification Plan – Better Effects as Book

- Exporting via “Extended” Export to Word function.



Summary

- While there may be some overhead on the export, the end result leads to a full document, without the maintenance drawbacks of needing to keep the section 4 structure current with Section 3. Some overhead can be diminished by automating the process.
- While the requirements should be stable once Section 4 is being populated, there is still the opportunity for change and re-arrangement.
- Therefore, some form of automation for Section 4 is a worthwhile endeavor to be setup by the DOORS team for any company that needs to provide consistent exports of specifications.

Appendix – Steps to Exporting a Document

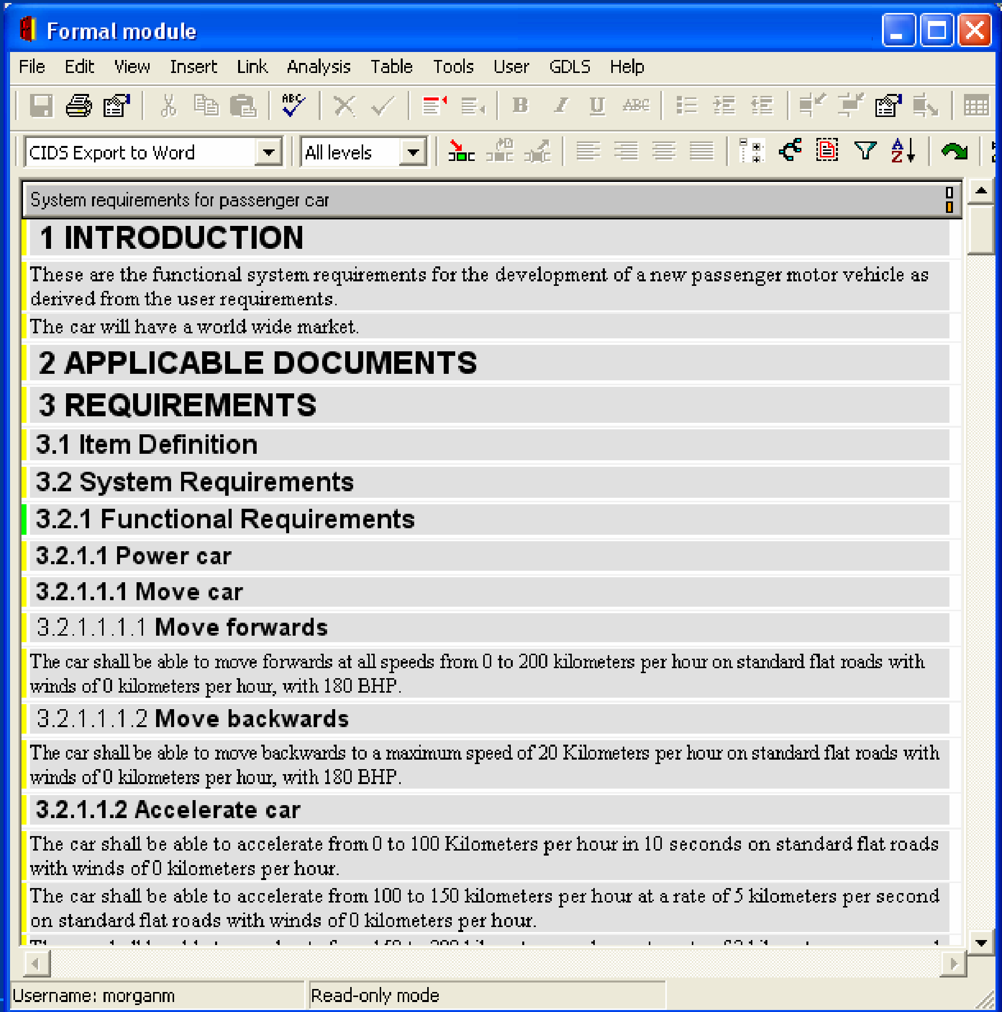
- The following steps are provided for exporting requirements as a specification in more detail.
- While a script can be prepared to automate these exports, this exercise will be covering the manual approach
- We have a customized version of the Export to Word function provided by Telelogic. Therefore snapshots may show extra features that won't be seen for the original function.

Export from DOORS to Word – GDLS Specific Options

- GDLS Extras include the following features:
  - Append the Object identifier on requirements
  - Append Variant names when the requirement is not Common?
  - Add N/A for empty sections
  - Browsing for a customized template starts at the desired folder, instead of the default Microsoft folder.
  - Capability to print Verification Plan information in document format for section 4.3.n

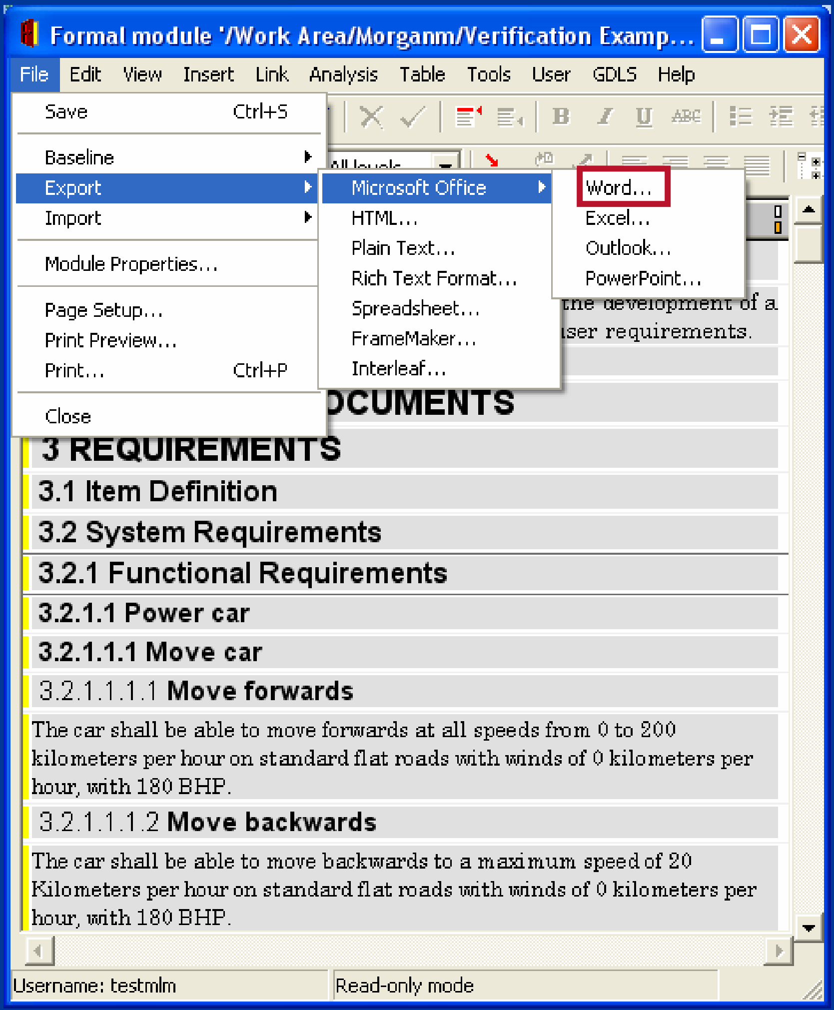
Export a CIDS – Export Main Document

- Export the document body from the DOORS module, including all headers and requirement objects within sections 1 through 6 satisfying the required filter.
- Only export the column containing the heading and object text attributes.

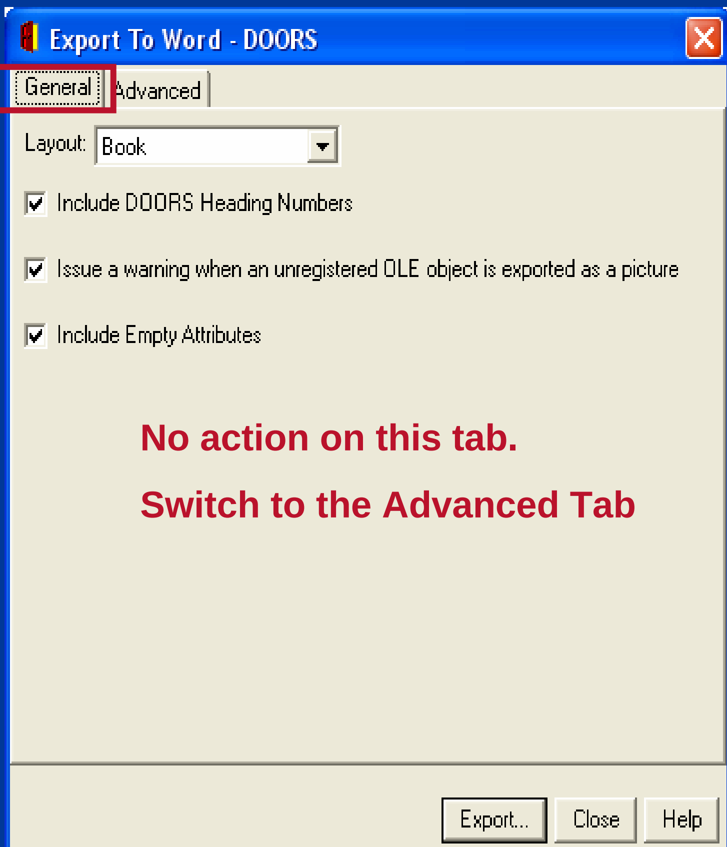


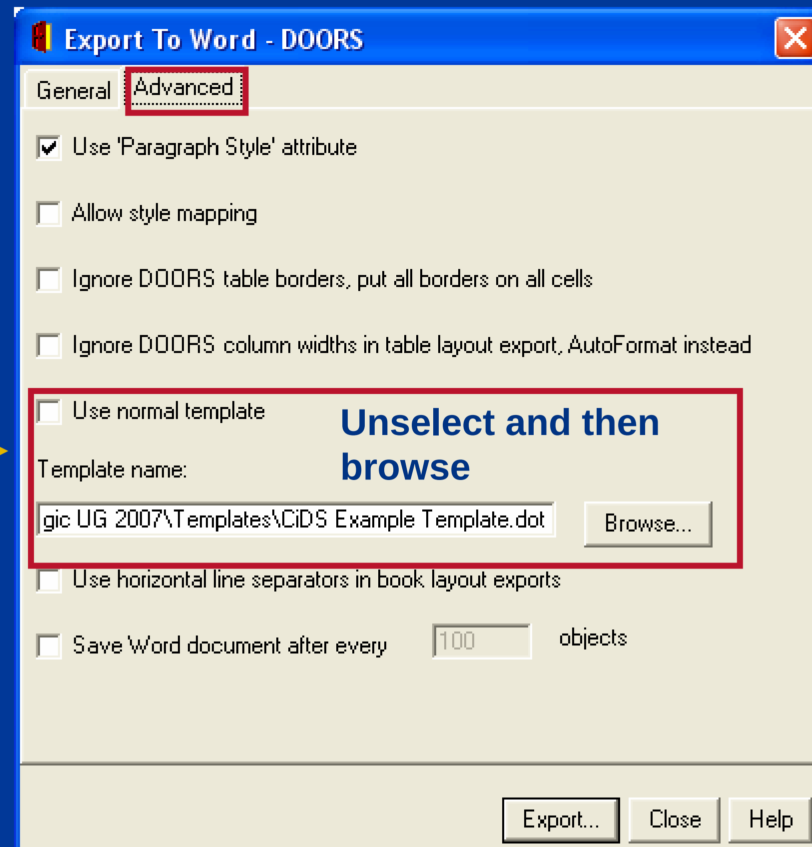
Export a CIDS – Export Main Document, Cont'd

- Initiate the "Export to Word" function



Export a CIDS – Export Main Document, Cont'd



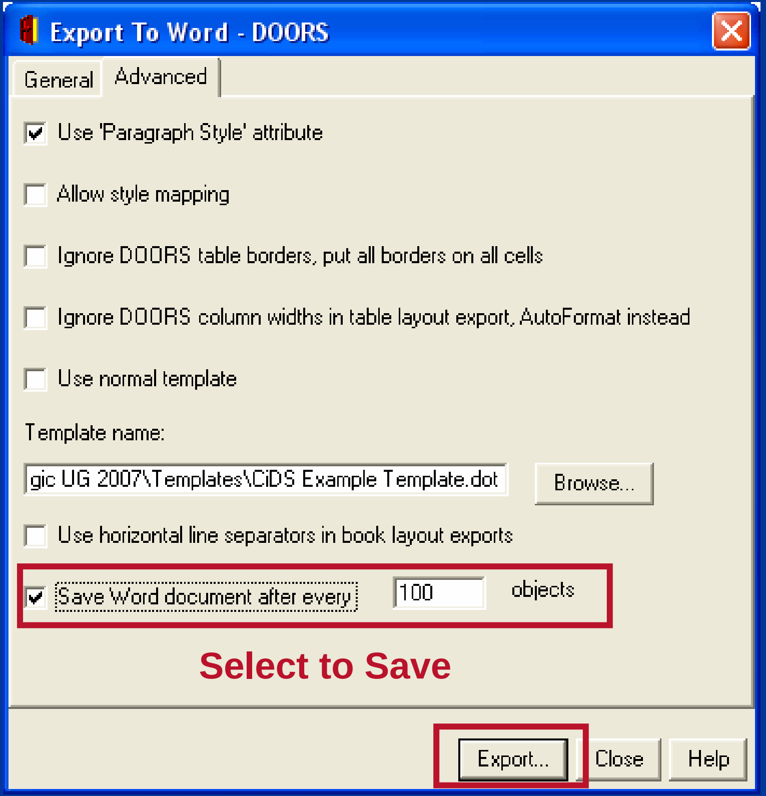


Export a CIDS – Export Main Document, Cont'd

- For large documents, its helpful to select "Save document after every 100 objects". When this option is selected, provide a file name once prompted (see next page for file name specifics).

•Click the **Export** button. Minimize the Microsoft Word window once it appears on screen (This process slightly speeds up the export as it doesn't have to keep refreshing the window)

•If you get a prompt about a style not available, click **OK**.



Export a CIDS – Export Main Document, Cont'd

- Save the file twice (The file name should include the DOORS module being exported and the date that it was exported from DOORS):
  - Save the newly generated Word document as a raw (untouched) file in your working directory:
  - Save again, but as a working file to contain the final CIDS document as follows.
- The working document will now be referred to as the "Main Document". Minimize this window for later usage.

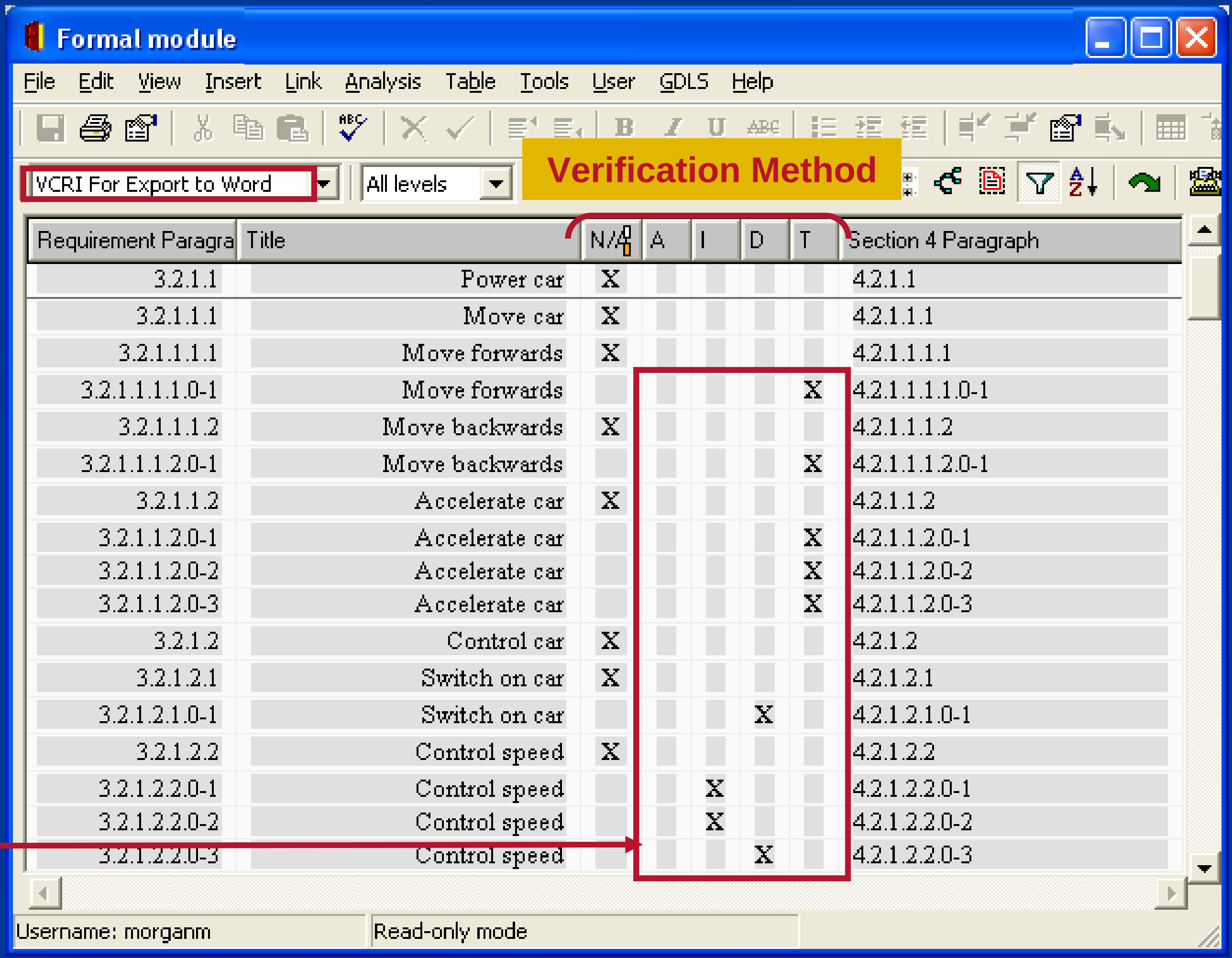
morganm@gdls.com

Export a CIDS – Export VCRI Matrix

- Export the VCRI matrix from the DOORS module, including all headers and requirement objects within sections 3.0, starting at 3.2, satisfying the required filter.
- Change to the view: “VCRI Export To Word”

Export a CIDS – Export VCRI Matrix, Cont’d

Select “VCRI Export To Word” view

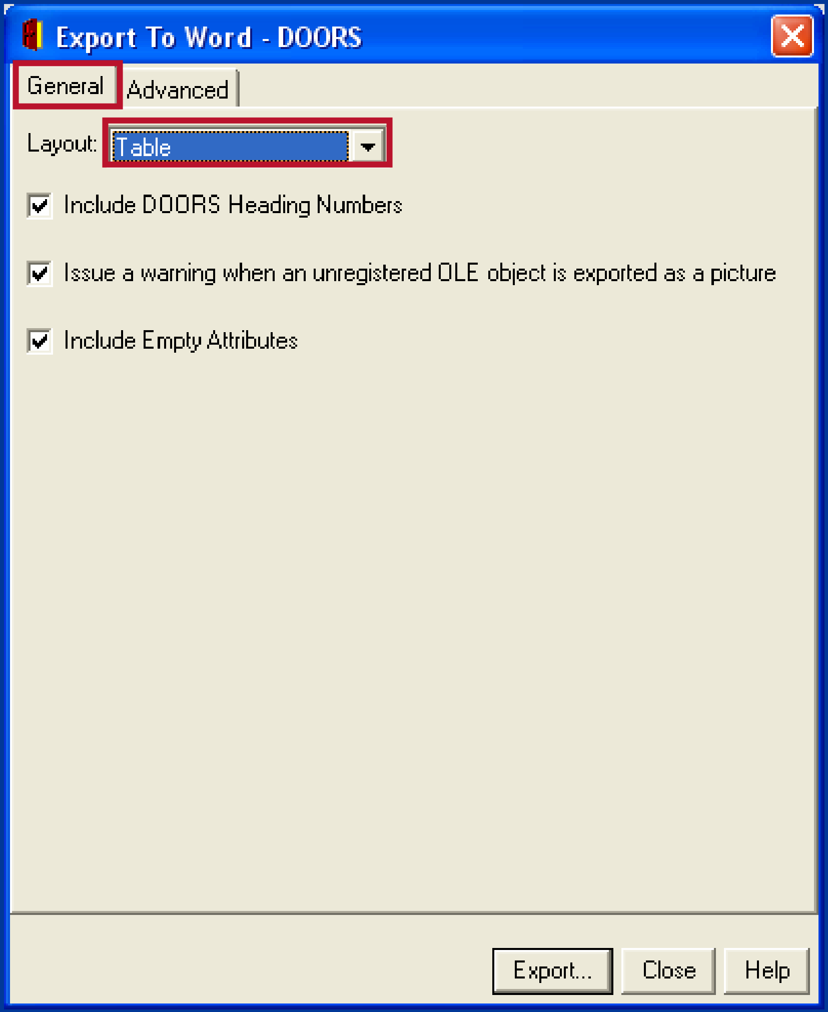


Requirement Paragra	Title	N/A	A	I	D	T	Section 4 Paragraph
3.2.1.1	Power car	X					4.2.1.1
3.2.1.1.1	Move car	X					4.2.1.1.1
3.2.1.1.1.1	Move forwards	X					4.2.1.1.1.1
3.2.1.1.1.1.0-1	Move forwards					X	4.2.1.1.1.1.0-1
3.2.1.1.1.2	Move backwards	X					4.2.1.1.1.2
3.2.1.1.1.2.0-1	Move backwards					X	4.2.1.1.1.2.0-1
3.2.1.1.2	Accelerate car	X					4.2.1.1.2
3.2.1.1.2.0-1	Accelerate car					X	4.2.1.1.2.0-1
3.2.1.1.2.0-2	Accelerate car					X	4.2.1.1.2.0-2
3.2.1.1.2.0-3	Accelerate car					X	4.2.1.1.2.0-3
3.2.1.2	Control car	X					4.2.1.2
3.2.1.2.1	Switch on car	X					4.2.1.2.1
3.2.1.2.1.0-1	Switch on car				X		4.2.1.2.1.0-1
3.2.1.2.2	Control speed	X					4.2.1.2.2
3.2.1.2.2.0-1	Control speed			X			4.2.1.2.2.0-1
3.2.1.2.2.0-2	Control speed			X			4.2.1.2.2.0-2
3.2.1.2.2.0-3	Control speed				X		4.2.1.2.2.0-3

Set via the Verification Editing view

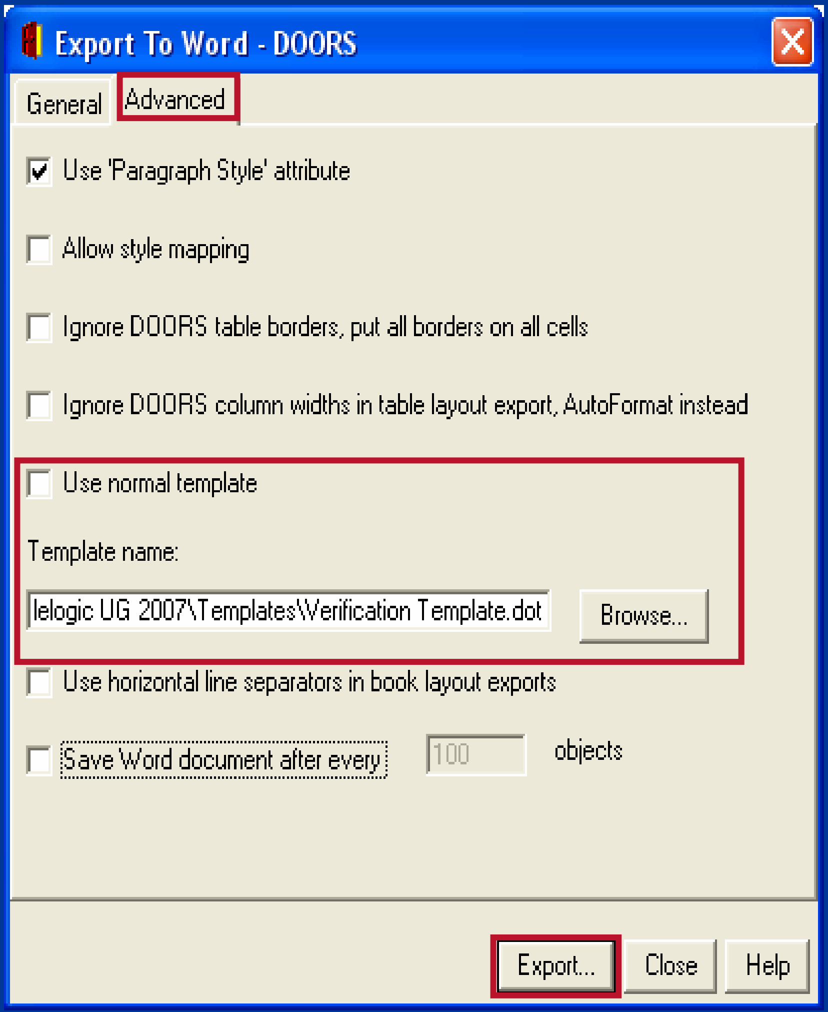
Export a CIDS – Export the VCRI Matrix, Cont'd

- Then select to export to Word using Table option on the General tab



Export a CIDS – Export the VCRI Matrix

- Switch to Advanced Key
- De-select to “Use normal template”, and browse to select the “Verification Template” in its place.
- Click the Export button. Minimize the MS Word file once it appears on screen (This process slightly speeds up the export as it doesn’t have to keep refreshing the window)

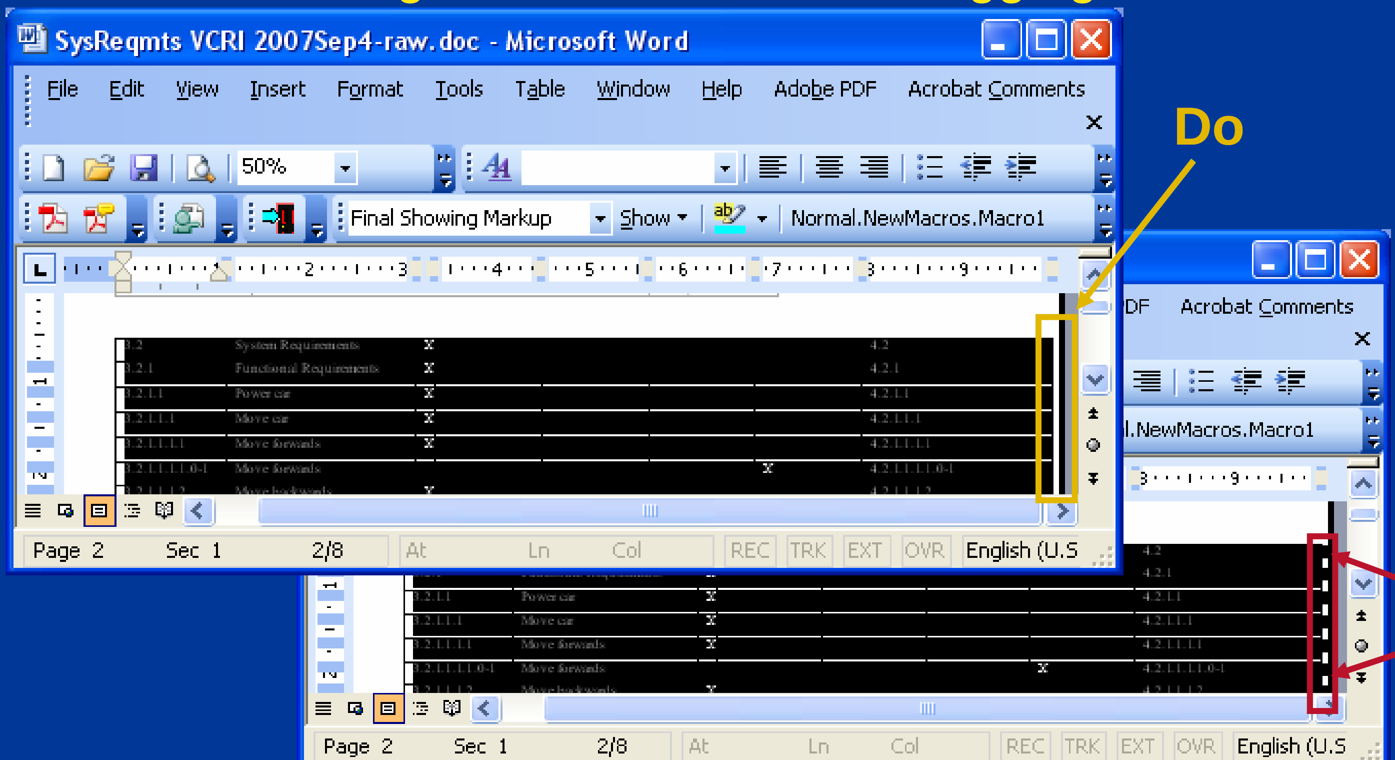


Export a CIDS – Export VCRI Matrix, Cont'd

- The resulting MS Word document includes:
  - the VCRI table template as an MS Word table. Optionally, it may be divided in two with the legend as separate from rest of table.
  - the exported VCRI contents, in a separate MS Word table.
- Save the file as a raw file in your selected working folder
- Scroll down to the exported table
- Delete the top row that contains the column header

Export a CIDS – Export VCRI Matrix, Cont'd

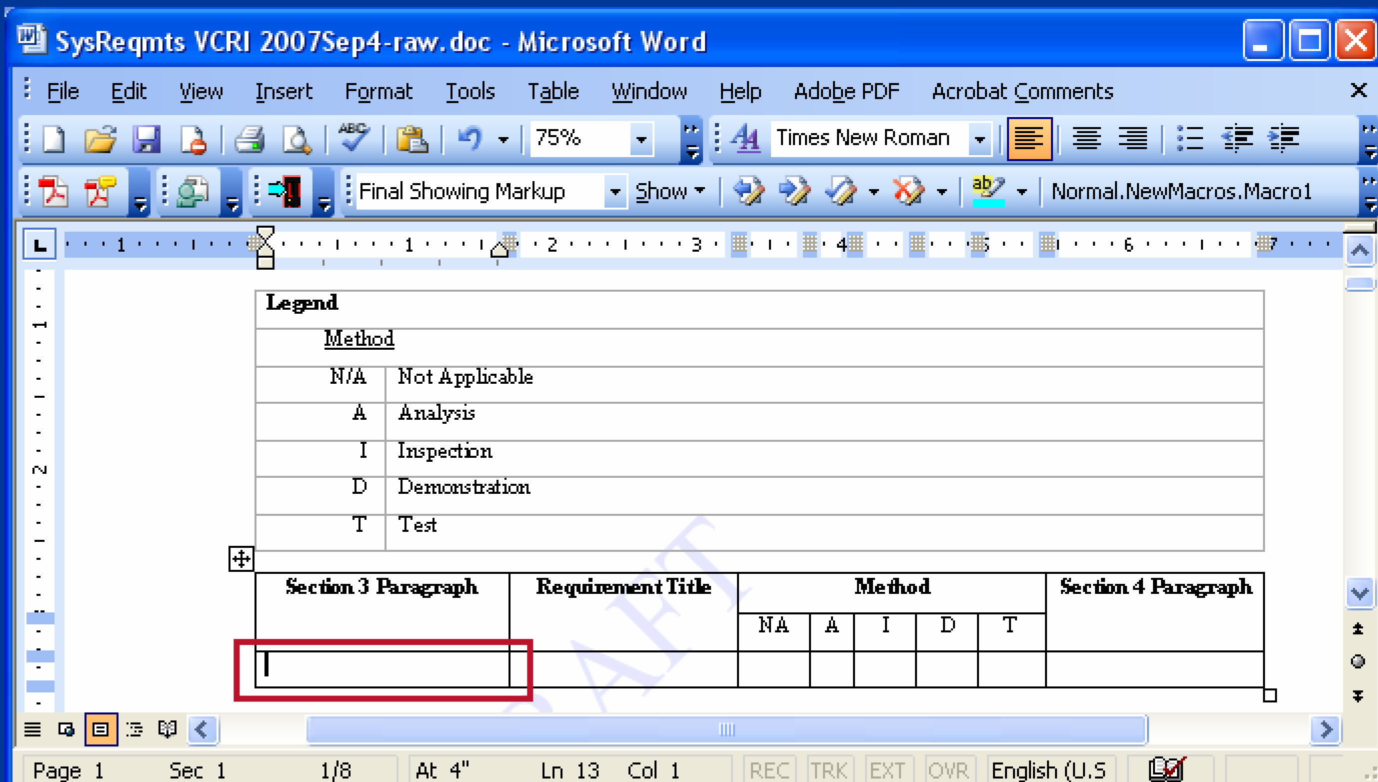
- Select all columns but not the right most control character column and select to Copy (CTRL-C). Do this by moving cursor to top of table, turning to black arrow and dragging across rows.



morganm@gdls.com
GENERAL DYNAMICS
Land Systems

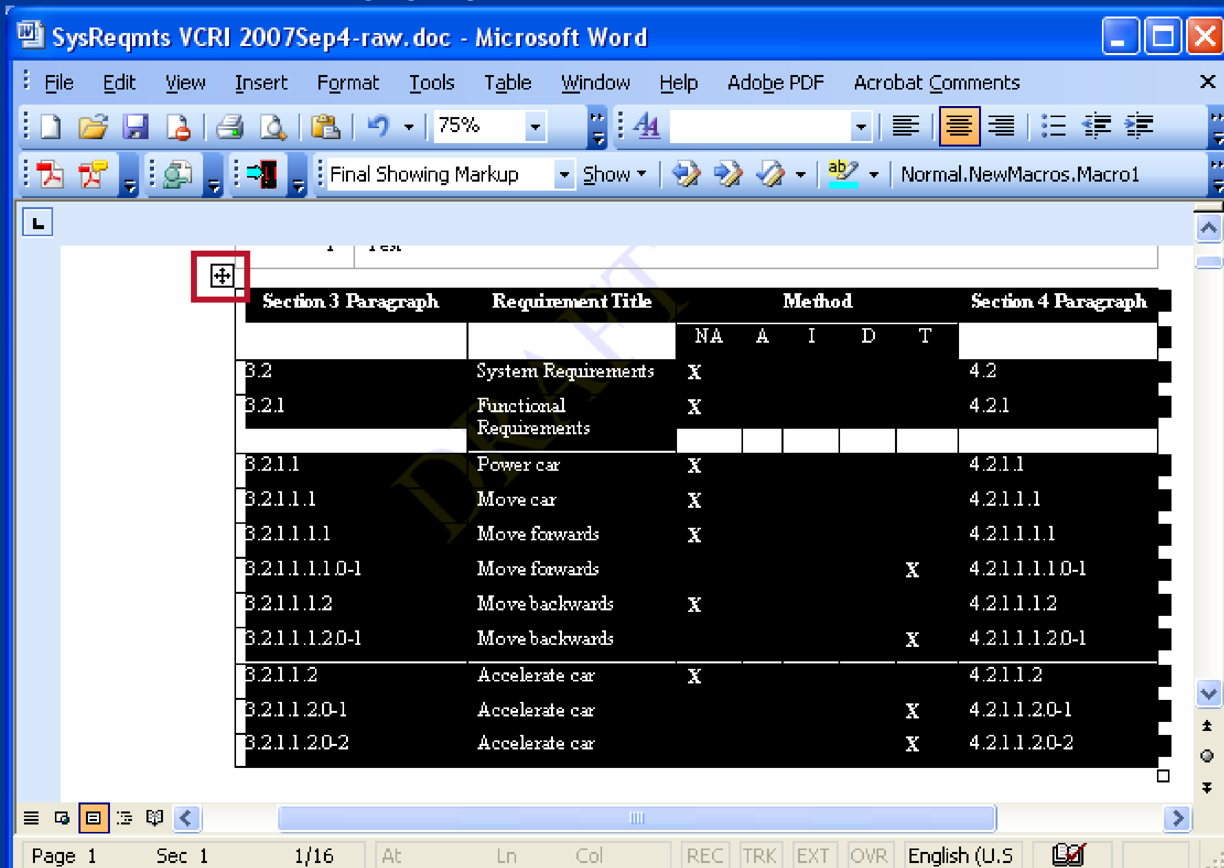
Export a CIDS – Export VCRI Matrix, Cont'd

- Scroll back to top and paste the VCRI contents from the clipboard into the leftmost cell of the first empty row in the VCRI table.



Export a CIDS – Export VCRI Matrix, Cont'd

- Select the newly populated VCRI formatted table and select to copy



Section 3 Paragraph	Requirement Title	Method					Section 4 Paragraph
		NA	A	I	D	T	
3.2	System Requirements	X					4.2
3.2.1	Functional Requirements	X					4.2.1
3.2.1.1	Power car	X					4.2.1.1
3.2.1.1.1	Move car	X					4.2.1.1.1
3.2.1.1.1.1	Move forwards	X					4.2.1.1.1.1
3.2.1.1.1.1.0-1	Move forwards					X	4.2.1.1.1.1.0-1
3.2.1.1.1.2	Move backwards	X					4.2.1.1.1.2
3.2.1.1.1.2.0-1	Move backwards					X	4.2.1.1.1.2.0-1
3.2.1.1.2	Accelerate car	X					4.2.1.1.2
3.2.1.1.2.0-1	Accelerate car					X	4.2.1.1.2.0-1
3.2.1.1.2.0-2	Accelerate car					X	4.2.1.1.2.0-2

Export a CIDS – Export VCRI Matrix, Cont'd

- Maximize the Main Document and move down the existing stub VCRI matrix. Select the stub VCRI and select Paste (CTRL-V).
- If the Legend is separate, Copy/Paste it also from the VCRI document to above this new table, keeping as a separate table.

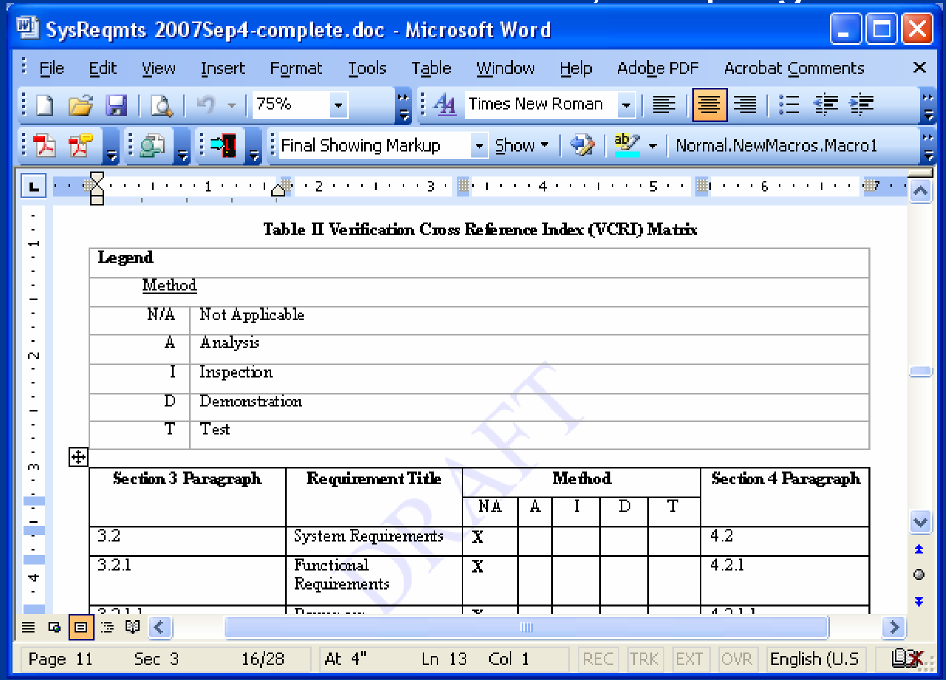


Table II Verification Cross Reference Index (VCRI) Matrix

Legend	
Method	
N/A	Not Applicable
A	Analysis
I	Inspection
D	Demonstration
T	Test

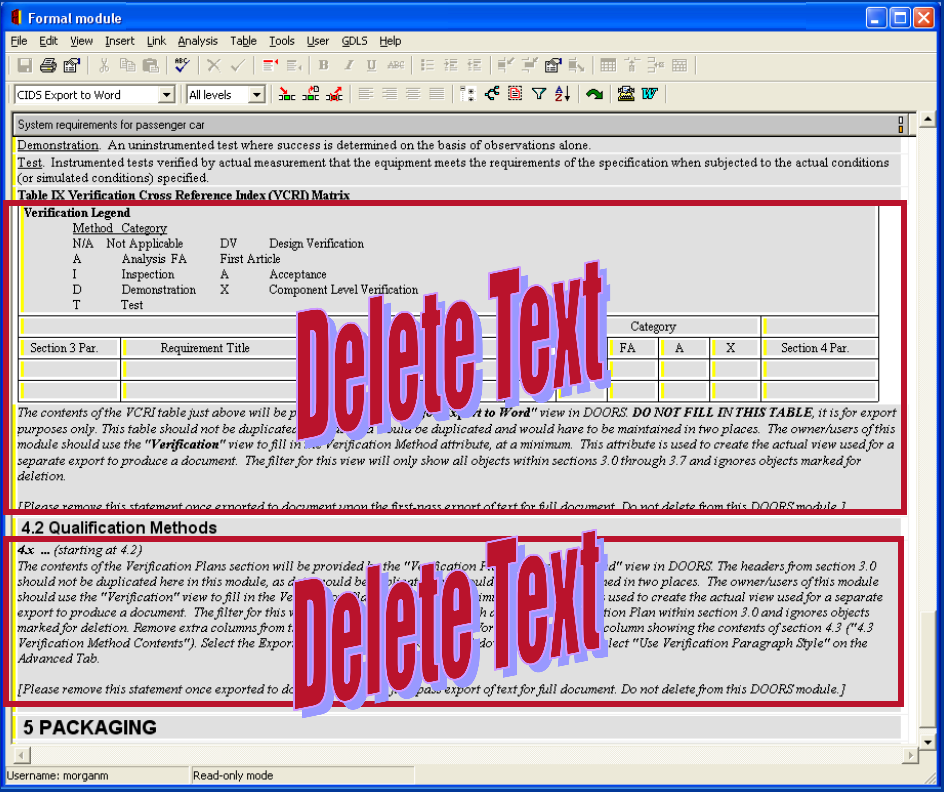
Section 3 Paragraph	Requirement Title	Method					Section 4 Paragraph
		NA	A	I	D	T	
3.2	System Requirements	X					4.2
3.2.1	Functional Requirements	X					4.2.1

Export a CIDS – Export VCRI Matrix, Cont'd

- Note, the new table now follows the Table Caption but did not replace the stub table.
- Scroll to the end of the new table. Delete the stub table and the italicized instructions that follow.
- If the heading row does not already repeat, select the first two rows and select Heading Rows Repeat from the Table pull-down menu. May need to click to unselect and then again to select (as a toggle).

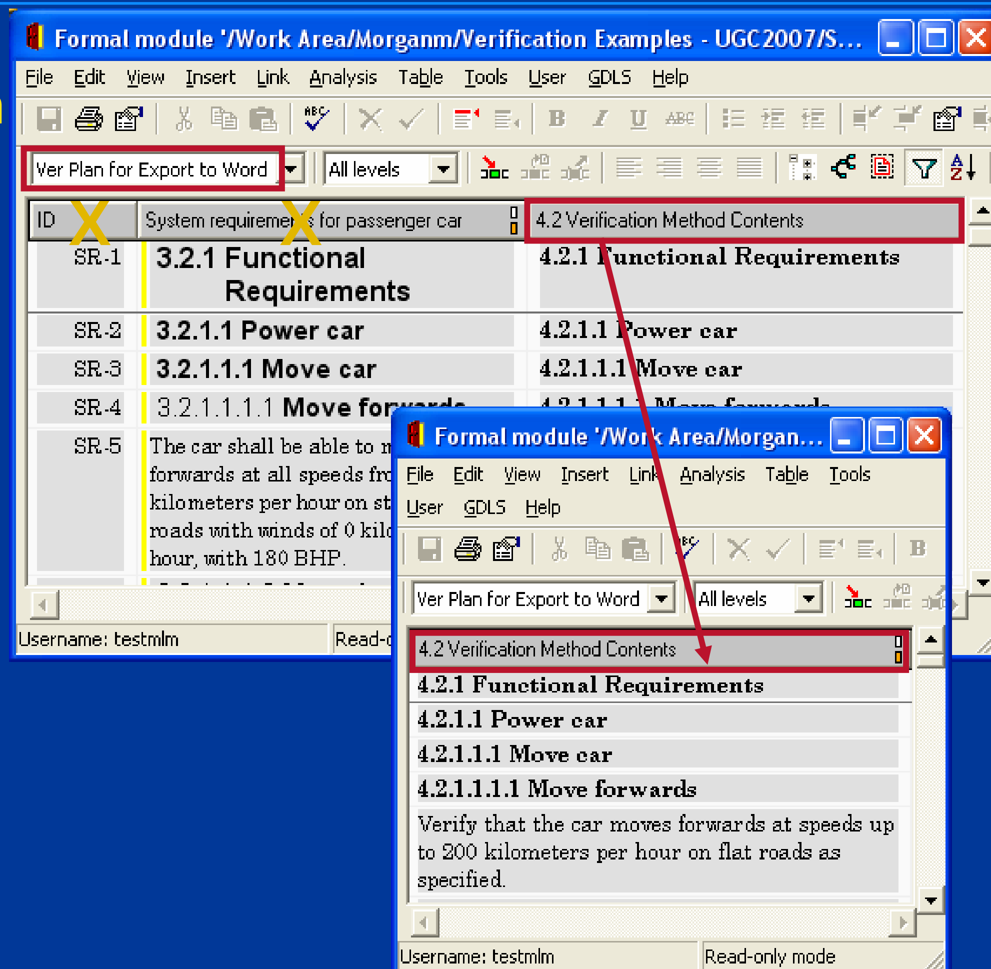
Exporting the VCRI Matrix, Cont’d

- Delete the instruction text in the main document and the VCRI template block.



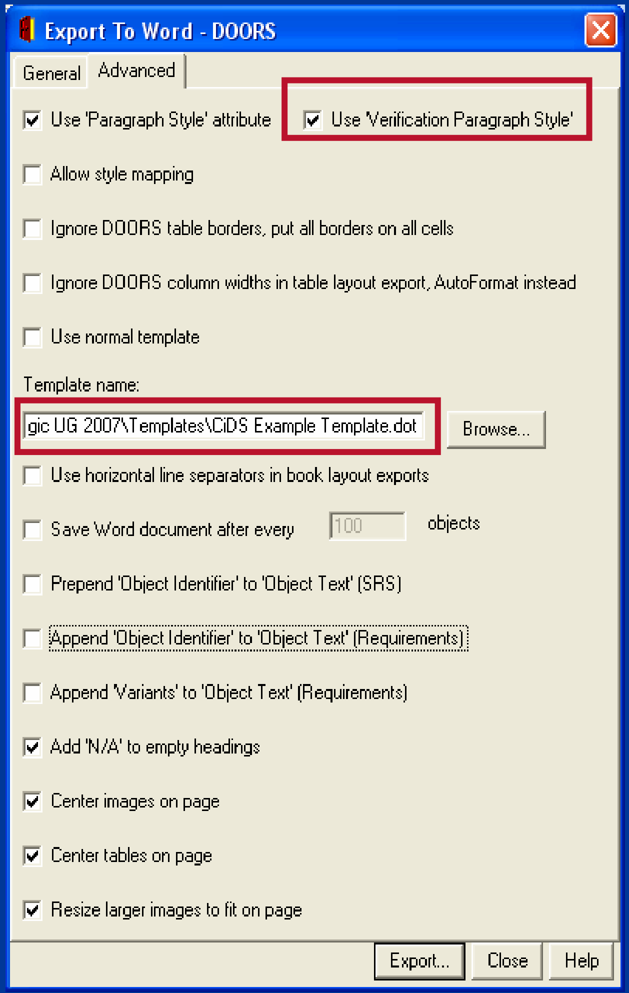
Export a CIDS – Export Verification Plan

- Change to the **"Ver Plan for Export to Word"** view. This not only sets up the columns, but filters on Section 3 only, where the Verification Plan attribute is not empty.
- Delete the Object ID and Section 3 columns before exporting, Leaving only the **"4.3 Verification Method Contents"** column only.



Export a CIDS – Export Verification Plan, Cont'd

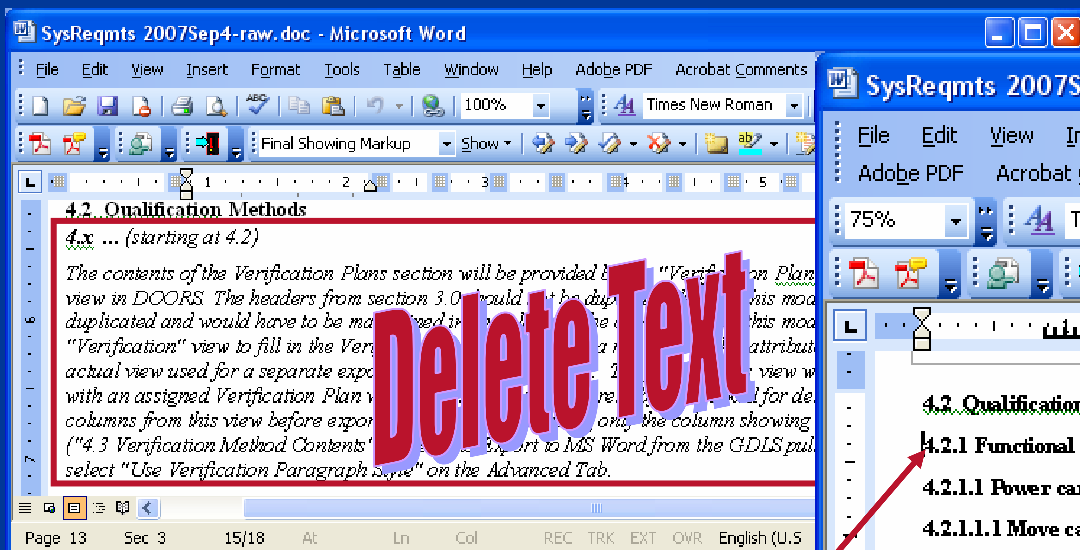
- Select Export to Word, via an extended version of the function.
  - ➢ General tab: no actions
  - ➢ Switch to the Advanced tab;
  - ➢ Select "Use 'Verification Paragraph Style" feature.
  - ➢ Uncheck "Use normal template"
  - ➢ Browse and select the same template you used for the Main Document to apply same styles to headers and text.
  - ➢ Export. A new MS Word document will be opened.

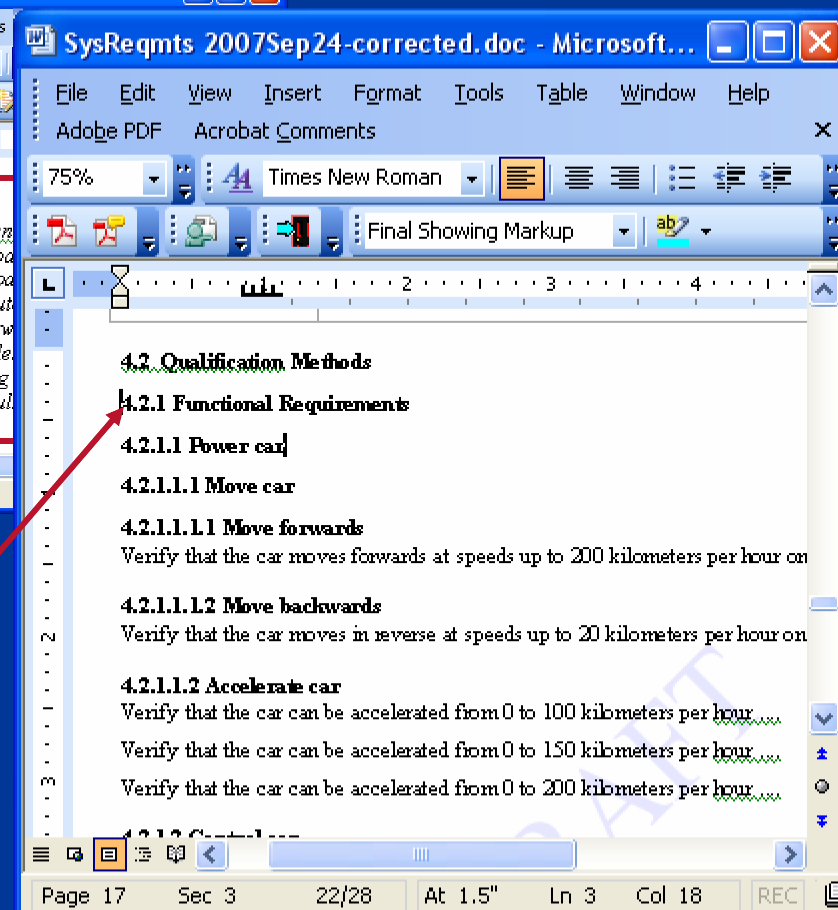


Export a CIDS – Export Verification Plan, Cont'd

- Save the newly generated Word document as a raw (untouched) file in your selected working folder
- Scroll down to the text containing the Verification Plan sections, select all of sections from 4.3.1 to the last section and copy (CTRL-C).
- Maximize the Main Document window, paste (CTRL-V) starting after the header, "4.2 Qualification Method".
- Remove the italicized instructions, if not removed during previous instructions for the VCRI table export.

Export a CIDS – Export Verification Plan, Cont'd





Replaces *Italic* Text

Alternative Exports for Verification Plan

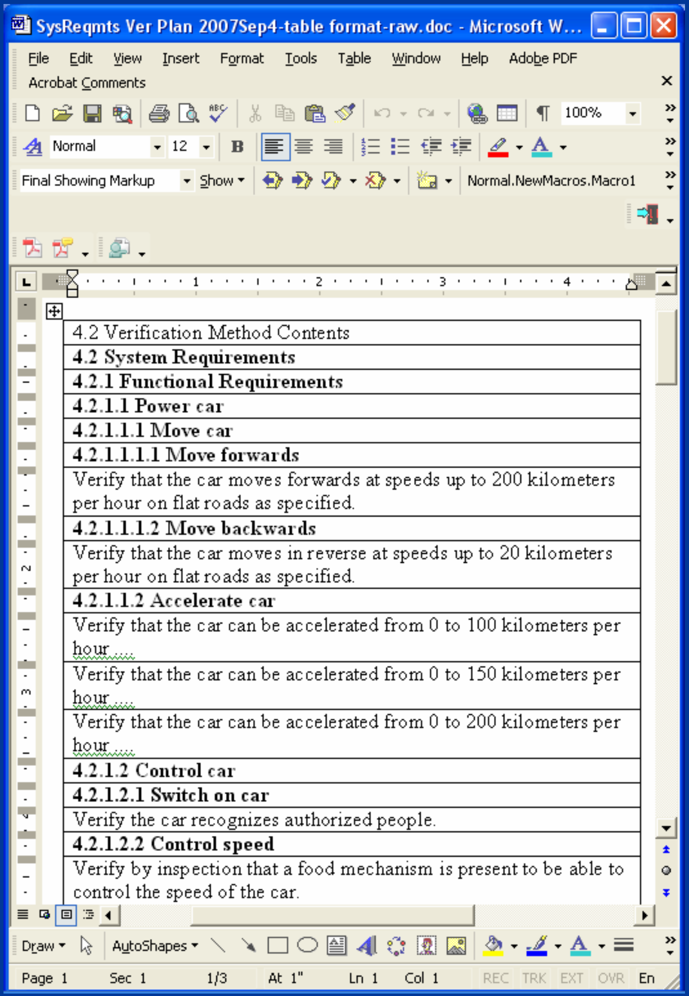
- Besides the capability of extending the Export to Word function, the following methods described in the following slides:
  - Export as a Table
  - Export as a Book (Undesired results, not recommended)

Verification Plan –Effects as Table

- The “4.2 Verification Method Contents” column could be exported as a Table to MS Word and then converted to text.
  - No styles are provided for Headers and would have to be applied by hand.
  - Can be done easily via the Style Formatting, but still takes time.

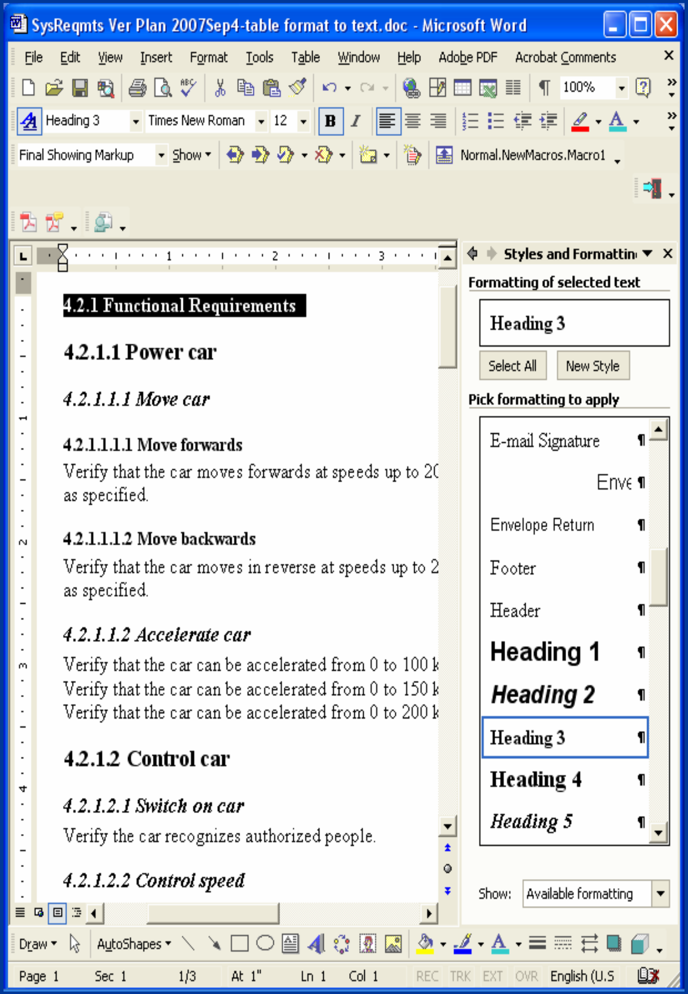
Verification Plan –Effects as Table

- Exporting via “Out of the Box” Export to Word function as a Table.



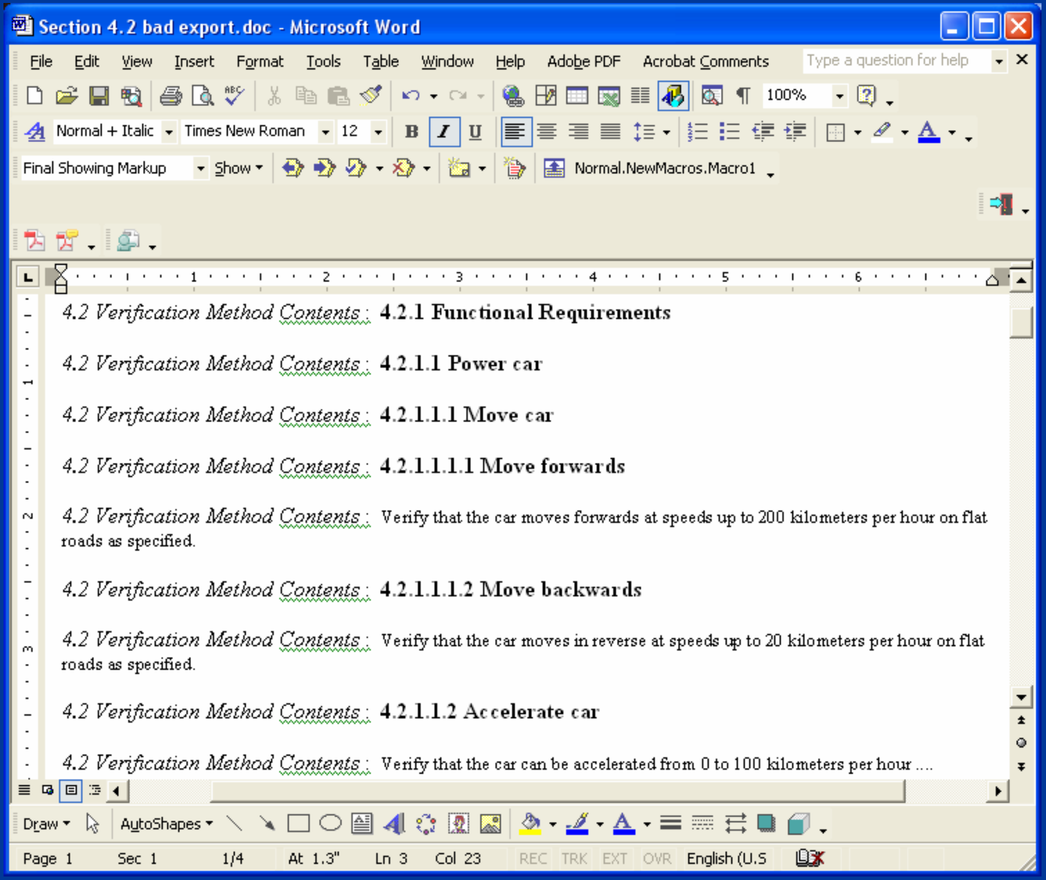
Verification Plan –Effects as Table

- Headers need to be formatted as MS Word Heading styles



Verification Plan – Undesired Effects as Book

- Exporting via “Out of the Box” Export to Word function.



Export a CIDS – Remaining Tasks

- Prepare Front Page supplying info for the following items:
  - Subsystem/component name for module
- Update the page headers for unique MS Word sections to include name of subsystem/component represented (e.g. engine)

Export a CIDS – Remaining Tasks, Cont'd

- For Tables and Figures: Captions should be on the same page as the table or figure: table caption before the table; figure captions after the table. If possible, keep the referencing object with the table/figure and caption, allowing all 3 objects to be on one page. This can be handled by manual page breaks or setting the paragraph style for the referencing requirement to be "Keep with Next".
- Update the Table of Contents, Table of Tables and Table of Figures as one of last steps.
- Switch to the Advanced Tab, no changes on General tab.

GENERAL DYNAMICS

Monika L. Morgan
General Dynamics Land Systems
morganm@gdls.com
586-825-5685

Integrating Test and Evaluation (T&E) Into DoD Acquisition Contracts

Ms. Darlene Mosser-Kerner
T&E Policy

Developmental Test & Evaluation
OUSD(AT&L)/Systems & Software Engineering

Outline

- The Challenge
- Test and Evaluation (T&E) Contract Issues Pre-Solicitation
- T&E Contract Solicitation Issues
- T&E Contract Execution Issues
- Integrating T&E in Acquisition Contracts
- Summary

The Challenge

- **T&E expertise is applied late – during source selection or after contract award**
- **Leads to contract related issues**
  - **Lack of appropriate contract requirements**
  - **Inappropriate contract incentives**
  - **Lack of adequate / appropriate test resources**
  - **Lack of adequate test time**
- **How can the T&E community help get better contracts developed, awarded, and executed?**

Pre-Solicitation T&E Issues

- **Requirements and Strategies**
  - **Development of evaluatable requirements**
  - **Development of an appropriate T&E strategy**
- **Establishment of appropriate contract incentives**
  - **De-emphasize single point test events – "first flight"**
  - **Demonstrate maturation of system and T&E program**
- **Scoping the test program**
  - **Timing and magnitude of the test effort**
  - **Number of test articles**
  - **Threats, targets**

Solicitation T&E Issues

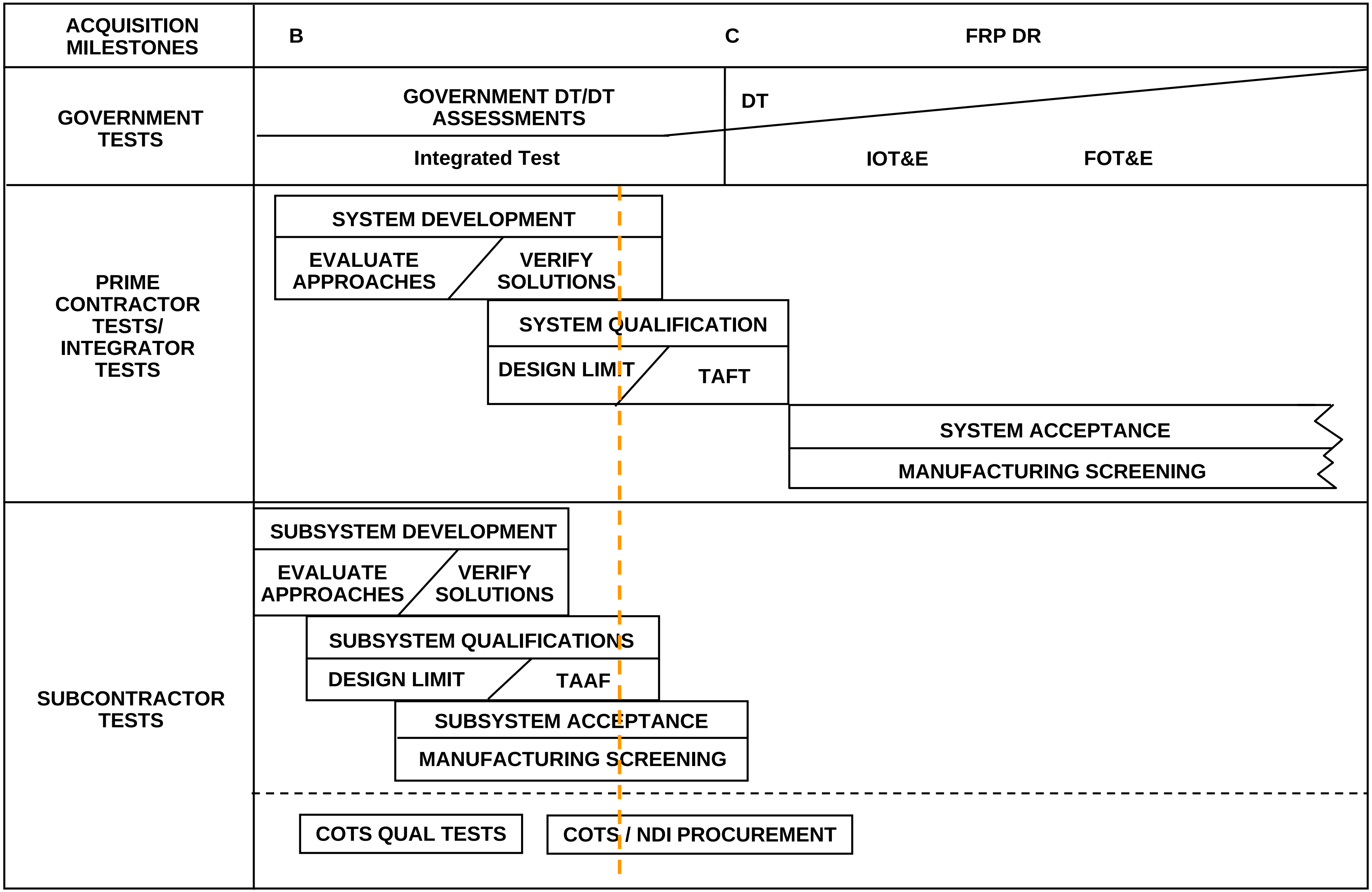
- **Development of the Statement of Objectives (SOO) and Statement of Work (SOW)**
- **Development of valid source selection evaluation factors and scoring criteria**
- **Participation on source selection teams**

Contract Execution T&E Issues

- Integration of Contractor, Government, and Operational teams - Integrated Test Team
- Working with Defense Contract Management Agency (DCMA)
- Test Operations
  - Sharing data
  - Deficiency identification and resolution
  - Safety concerns
  - Environmental issues
  - Resource management

System Test Plan (STP)

DEVELOPMENTAL TEST & EVALUATION



Integrating T&E In Contracts - Ideas

- **Develop T&E strategy (draft TEMP) prior to Request For Proposal (RFP) development**
- **Ensure requirements are evaluatable**
- **Use Contractor T&E approach in source selection criteria**
- **Consider Test execution issues in SOO/SOW**
  - **Integrated CT, DT, OT**
  - **Information sharing**

Next Steps

- Engage with program management and contracting communities
- Publish T&E contracting guidebook – Summer 08
- Request your inputs to make the guidance useful to all concerned

Contact Info

Darlene Mosser-Kerner

darlene.mosser-kerner (at) osd.mil

Contact us to provide feedback and share your experience

Air Force Research Laboratory

Airbase Technologies Division

Tyndall Air Force Base, Florida

AFRL Research Sites

Force Protection Technology

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

Research Areas

Engineering Mechanics
- Blast Resistant Materials
- Structural Survivability

Robotics
- Explosive Ordnance Disposal
- Base Defense & Security

Security Technologies
- Agent Detection & Characterization
- IED Detection

Reactive Chemical Systems
- Development/Demo/Testing
- Explosive Operations

Benefits to Warfighter

- Enhanced Blast/Fragmentation Weapon Protection
- Reduced Manpower/Time/Cost for Range Clearance Ops
- Increased Safety of Deployed Personnel
- Increased Protection from Chemical / Biological Threats

Robotic Technologies

Research Areas

- Advanced Technologies Development
- Integrated Base Defense Technologies
- Robotic EOD Technologies
- Automated UXO Response Technologies
- Robotics for Airbase Operations and Support

Benefits to Warfighter

- Reduced manpower/time/cost for Range Clearance Ops
- Increased safety of deployed personnel
- Technical expertise
- Reduction of development time with existing systems and new capabilities

Capabilities

Test Ranges Approved for Large Scale Robotic Vehicles

Technologies

Developed & Transitioned Technology

Bombot

MACE

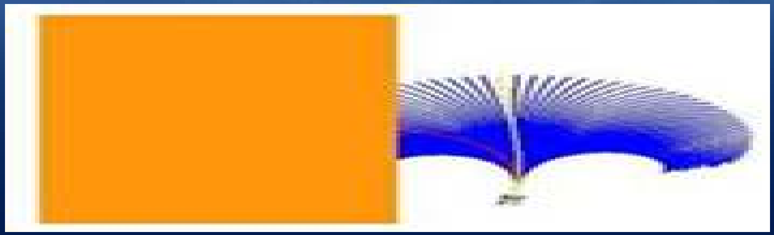
Robo-Trencher

REDCAR

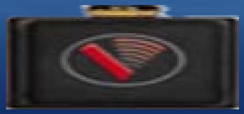
ARTS

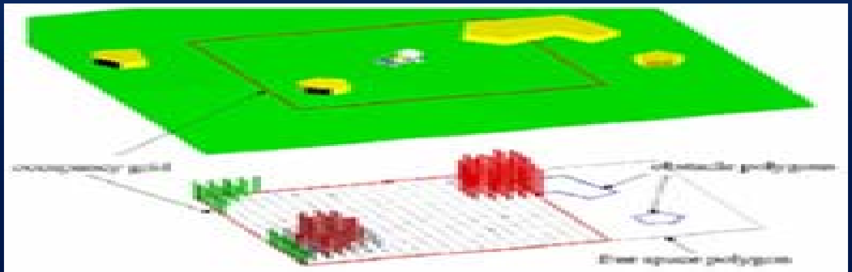
Robotic ATV Carrier

Advanced Technologies Development



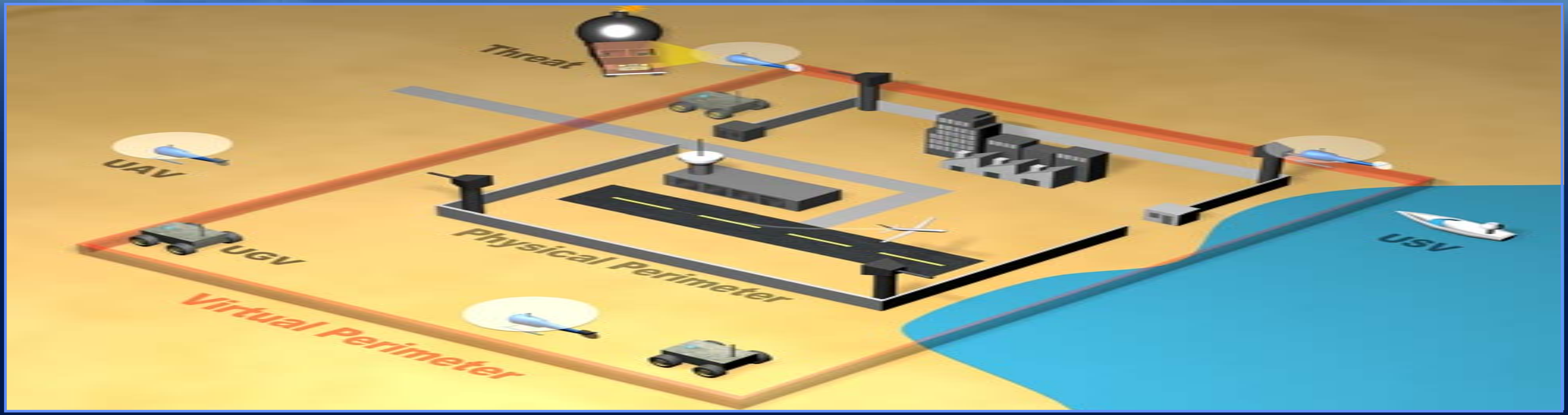
$$\frac{a_y}{g} = \frac{t/2 + \varphi h}{h}$$





- Advanced Technology Development expands technology required for unmanned systems to operate autonomously
- Focus is on technology considered necessary for an autonomous system
- New technology developed or current technology improved in a modular fashion
- Develop enabling robotics technology in the areas of Autonomous mobility control, tactical behaviors, world modeling, mission planning, sensor fusion, and robotic perception
- Transition technology modules into applied projects focusing on specific applications

Integrated Base Defense

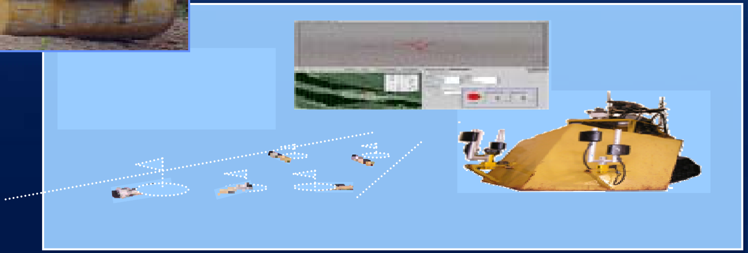


- Develop automated technology to augment the security force mission
- Provide perimeter security to protect installations from emerging threats
- Integrate robotic ground, air, and sea systems into a seamless network with existing USAF security system architectures – Integrated Base Defense Security System (IBDSS)
- Develop object classification capability to determine ground traversability
- Develop target interdiction model/planner
- Develop technology to support intruder detection on the move
- Conduct warfighter airfield security experiment

Robotic EOD Technologies

- Increase EOD operations conducted mostly by robotic systems under the supervision of EOD personnel
- Detection and neutralization of conventional unexploded military munitions using experience based and adaptive artificial intelligence
- Employ state of the art sensors on robotic systems for detection of non-standard explosive threats and neutralization of conventional explosive devices
- Increase the operational capability of the EOD mission personnel by providing technology solutions to decrease mission time and increase stand-off to save lives putting unmanned systems in harm's way

Automated UXO Response



- Validate UXO detection methods using an unmanned air vehicle
- Unmanned ground vehicle autonomously travel to these targets for verification and elimination utilizing a multi-shot SMUD platform
- Technology will enhance collaborative engagement technology development between UAVs and UGVs
- Includes multiple autonomous solutions to the range clearance issue
- Develop technology to support UXO range clearance operations
- Integrate UXO detection techniques between a UAV and UGV platform
- Demonstrate automated detection and clearance of unexploded items

Robotics for Airbase Operations and Support

- Develop robotic technology to allow for unmanned firefighting operations in hazardous locations
- Increase the efficiency of ground support operations through automation of the ground refueling process for the planned F-35 JSF training mission at Eglin AFB
- Protect personnel during transport and handling of remains and prevent the spread of contamination during recovery and delivery

Points of Contact

THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

Points of Contact:

Strategic Research Manager
Mr. Al Nease
850-283-3705 DSN 523-3705
Al.Nease@tyndall.af.mil

Robotics Group Lead
Mr. Walter Waltz
850-283-3725 DSN 523-3725
Walt.Waltz@tyndall.af.mil

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

U.S. General Services Administration

Federal Acquisition Service

Frank Parker
Contracting Officer
General Services Administration

February 26, 2008

Who are we?

GSA Federal Acquisition Service…A New Service Representing

General Supplies and Services

Integrated Technology Services

Assisted Acquisition Services

Travel, Motor Vehicle, & Card Services

Today's Topic

Enabling GSA "Tools" (Professional Services Schedule contracts)

GSA e-Tools

GSA Support

NDIA’s Principle Missions

……………are to improve weapons technology, improve defense management, and maintain a strong science-industry-defense team continually responsive to all needs of the research, development, test & evaluation, production, logistics and management phase of national preparedness…..

Conference Objectives

“Test and Evaluation of Autonomous Systems

&

The Role of the T & E Community in the Requirements Process

Enabling Tools

GSA Professional Services Schedule Contracts

Commercial Item Acquisition

Expanding the use of commercial items in DoD systems offers the DoD opportunities for reduced cycle time, faster insertion of new technology, lower life-cycle costs, greater reliability and availability, and support from a more robust industrial base. It is a fact that for many technologies that are critical to military systems, the commercial marketplace-and not the DoD-now drives the pace of innovation and development.

DoD Extension to PMBOK ® Guide
June 2003

GSA Schedules Program

What is a Schedule?

- GSA Awarded Competitive IDIQ contracts
- Mirrors Commercial Buying Practices
- Long-term Contracts Awarded to Multiple Companies
  - 5 yrs. With Three 5-yr. Options
- Forty-three Schedules Offer 11 Million-Plus Products & Srv.
- Huge Selection: Over 14,000 Companies Represented on Nearly 18,000 Contracts

Multiple Award Schedule Benefits

All Competition Requirements Have Been Met

- No Synopsis Required
- Prices Have Been Deemed Fair & Reasonable
- Terms and Conditions Have Been Pre-negotiated
- Reduced Need For Front-End Procurement Personnel
- Reduced Procurement Lead Time
- Minimizes Documentation Required
- Customized Solutions
- Direct Relationship With Contractors
- No Additional Administrative Fees
- Risk of Protest is Low

GSA Professional Services
(samples)

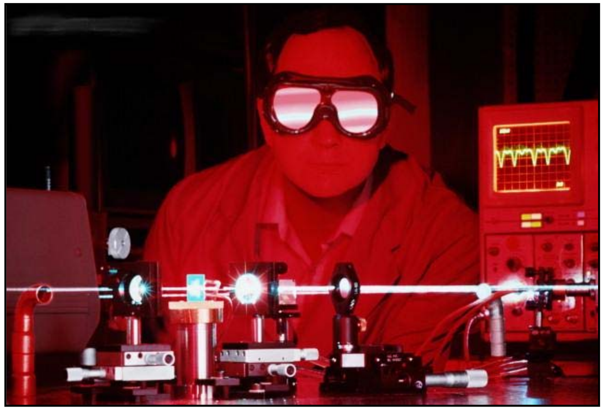
Professional Engineering Services

Mission Oriented Business Integrated Services

Professional Engineering Services - Schedule 871

Professional Engineering Services Scope of Schedule

This schedule provides a comprehensive vehicle for Federal agencies to use when obtaining all types of engineering services



Professional Engineering Services (Schedule 871) Industry Partners

Over 800 Contractors as of January 2008, including:

- Large Businesses
- Small Businesses
  - Disadvantaged
  - HUBZone
  - Veteran-owned
  - SDVOB
  - Women-owned

Professional Engineering Services-871

Special Item Numbers (SINs):

- 871-1 Strategic Planning for Technology Programs/Activities
- 871-2 Concept Development and Requirements Analysis
- 871-3 System Design, Engineering and Integration
- 871-4 Test and Evaluation
- 871-5 Integrated Logistics Support
- 871-6 Acquisition and Life Cycle Management
- 871-7 Construction Management

Mission Oriented Business Integrated Services (MOBIS)-874

Special Item Numbers (SINs):

874-1 Consulting Services

874-2 Facilitation Services

874-3 Survey Services

874-4 Training Services

874-5 Support Products

874-6 Competitive Sourcing Support

874-7 Program Integration and Project Management Services

874-99 Introduction of New Services

GSA Tools for Test & Evaluation

T&E Metrics for Suitability and Sustainability

SIN 871-6 Acquisition Life Cycle Management (PES)

SIN 871-5 Integrated Logistics Support (PES)

SIN 874-7 Program Integration and Project Management (MOBIS)

Reducing Total Ownership Costs and Role of T&E, SE and Logistics

SIN 871-6 Acquisition Life Cycle Management (PES)

SIN 871-2 Concept Development and Requirements Analysis (PES)

SIN 871-5 Integrated Logistics Support (PES)

SIN 874-7 Program Integration and Project Management (MOBIS)

Test Planning to Assure Priority for Assessment of S&S

SIN 871-3 Systems Design, Engineering and Integration (PES)

SIN 871-4 Test and Evaluation (PES)

SIN 874-1 Consulting Services (MOBIS)

SIN 874-7 Program Integration and Project Management (MOBIS)

Planning and Implementing Sustainability as a KKP Effectively

SIN 871-3 Systems Design, Engineering and Integration (PES)

SIN 871-4 Test and Evaluation (PES)

SIN 871-5 Integrated Logistics Support (PES)

SIN 874-7 Program Integration and Project Management (MOBIS)

Design Techniques such as Conditioned-Based Maintenance and its T&E

SIN 871-3 Systems Design, Engineering and Integration (PES)

SIN 871-4 Test and Evaluation (PES)

Test Methodology

SIN 871-2 Concept Development and Requirements Analysis (PES)

SIN 871-3 Systems Design, Engineering and Integration (PES)

SIN 871-4 Test and Evaluation (PES)

SIN 874-1 Consulting Services (MOBIS)

Testing for Realistic Estimates for Reliability

SIN 871-Test and Evaluation (PES)

SIN 874-7 Program Integration and Project Management (MOBIS)

Reducing Total Cost of Ownership

SIN 871-1 Strategic Planning for Technology Programs (PES)

SIN 871-5 Integrated Logistics Support (PES)

SIN 871-6 Acquisition Life Cycle Management (PES)

SIN 874-1 Consulting Services (MOBIS)

Technologies to Reduce Life Cycle Cost

SIN 871-1 Strategic Planning for Technology Programs (PES)

SIN 871-2 Concept Development and Requirements Analysis (PES)

Field Test Data and Archiving

SIN 871-4 Test and Evaluation (PES)

SIN 871-6 Acquisition Life Cycle Management (PES)

SIN 874-7 Program Integration and Project Management (MOBIS)

Feedback Sustainment Lessons to Improve Requirements, Programming T&E and Acquisition Process

SIN 874-1 Consulting Services (MOBIS)

SIN 871-5 Integrated Logistics Support (PES)

SIN 871-6 Acquisition Life Cycle Management (PES)

SIN 874-7 Program Integration and Project Management (MOBIS)

E-tools

E-Tools: Bringing Buyers and Sellers Together

GSA *Advantage!*®

e-Buy

e-Library

Market Research Tools

Buyer

GSA Schedules e-Library
GSA Federal Supply Service

- Research vendors

GSA Advantage!®
www.gsaAdvantage.gov

- Research vendors
- Research pricing

GSA e-Buy

- RFQ/RFI
- Obtain quotes

Market Research Web Address

Schedules E-Library

www.fss.gsa.gov/elibrary

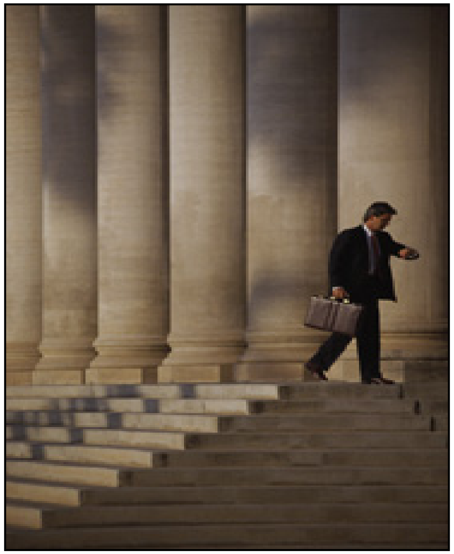
GSA *Advantage!*®

www.gsaAdvantage.gov

GSA e-Buy

access through GSA *Advantage!*®

www.gsaAdvantage.gov



GSA Support

Support Provided By GSA

Agency outreach: guidance, training & education

Industry outreach: promote, facilitate the growth of schedules supplier base

Expedite awards/mods of “potential” suppliers

Review SOWs

Federal Acquisition Service

THANK YOU!

Frank Parker

(253) 931-7951

Frank.parker@gsa.gov

Opportunities to Optimize the Operational Use of Unmanned Aircraft Systems and Gain Synergy in Developing New Capabilities

24th Annual National Test & Evaluation Conference
February 27, 2008

GAO's Mission and Related Work

- GAO is the audit, evaluation and investigative arm of Congress. It supports Congress in meeting its constitutional responsibilities and helps improve the performance and accountability of the federal government by
  - examining the use of public funds;
  - evaluating federal programs and policies; and
  - providing analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions.

- At Congress's request, GAO has assessed various aspects of the Department of Defense's (DOD) management and acquisition of intelligence, surveillance, and reconnaissance (ISR) assets, including the military services' unmanned aircraft systems (UAS) programs.

Background

- Battlefield commanders carrying out ongoing operations are supported by DOD's ISR assets, some of which are UAS.
- To meet the growing demand for ISR assets at every level of command, DOD is investing in several ISR systems, including UAS.
- DOD plans to invest more than $21 billion in UAS from fiscal year 2007 through fiscal year 2013.
- Each of the military services, as well as the U.S. Special Operations Command, operates UAS. As of September 2007, DOD components had more than 5,000 unmanned aircraft in inventory.

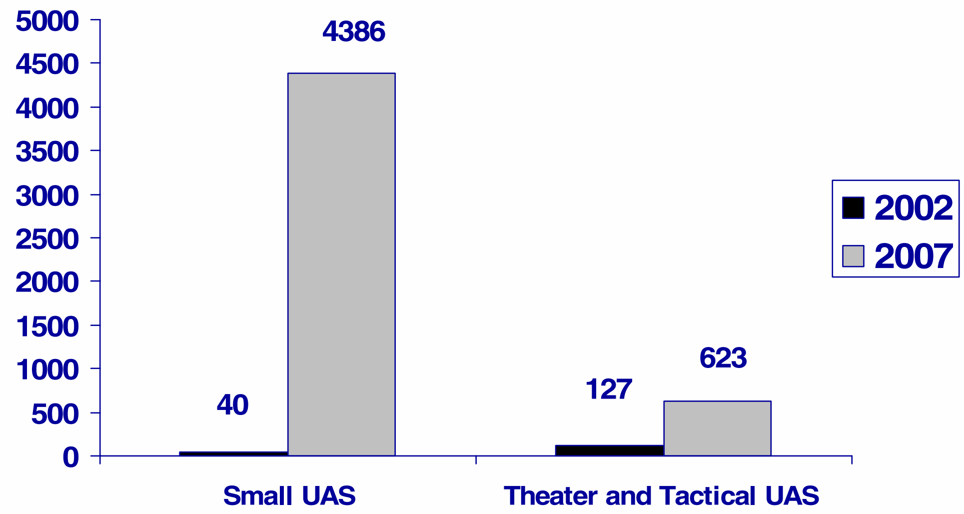
Background (continued)

- Acquisition of higher cost and more complex unmanned systems raised visibility and increased congressional scrutiny

- As with other major weapon systems, Congress wants
  -- well-managed acquisition programs meeting cost, schedule, and performance goals
  -- fielded systems providing the warfighter with the capabilities needed on time
  -- emphasis on jointness, limited duplication, and strategic portfolio management of unmanned assets

Unmanned Aircraft Inventory Increase, 2002-2007

- From 2002-2007, DOD substantially increased its inventory of unmanned aircraft.
- The largest increase was in small unmanned aircraft; e.g., the RQ-11 Raven and the RQ-13 Dragon Eye.
- Theater and Tactical unmanned aircraft include the MQ-1 Predator and the RQ-7 Shadow 200.



Source: GAO analysis of DOD data.
Note: Data as of September 2007. Small UAS weigh less than 10 pounds, Theater and Tactical more than 10 pounds.

General Observations on DOD's Ability to Optimize the Operational Use of UAS

- DOD has experienced a high level of mission success with UAS in ongoing operations. For example, UAS have been used to identify time-critical targets and to strike enemy positions to defeat opposing forces.

- While DOD has taken steps, GAO has reported that DOD has experienced difficulties in the management of its UAS programs in the following specific areas:
  – Strategic planning
  – Operational challenges
  – Performance measurement

Strategic Planning

- GAO's prior work has found that DOD lacks a robust oversight framework and a strategic plan to guide UAS development and investment decisions, to include key elements such as a clear link between goals, capabilities, funding priorities, and needs.
- DOD has established oversight bodies, such as the UAS Planning Task Force and the Joint UAS Center of Excellence, to facilitate planning and coordination. However, these entities are advisory bodies and lack directive authority.
- In lieu of establishing an executive agent for UAS, DOD recently established a new Task Force to "lead a DOD-wide effort to coordinate UAS issues and to develop a way ahead to enhance operations, enable interdependencies, and streamline acquisition."
- At this point, it is unclear whether the Task Force has the purview and authority to resolve the management challenges GAO has previously identified.

Operational Challenges

- DOD components have established guidance to facilitate the integration of UAS into combat operations, such as multi-service tactics, techniques, and procedures, along with a Joint UAS concept of operations.

- However, commanders face challenges in fully optimizing the use of UAS assets, due in part to the growing number of UAS. These challenges include:
  - Limited interoperability
  - Electromagnetic spectrum constraints
  - Lack of DOD-wide procedures for the advanced coordination of UAS into a theater of operations

Operational Challenges (continued)

- While DOD is taking several positive steps, we reported that the department’s strategic approach to managing its current UAS assets is not enabling DOD to fully optimize its use of these assets.
- U.S. Strategic Command’s Joint Functional Component Command for ISR (JFCC-ISR) manages the annual process for allocating available ISR assets to the combatant commanders to meet theater-level needs, including UAS. However, JFCC-ISR has limited visibility into national and allied ISR assets, and lacks visibility into UAS assets embedded and controlled by tactical units.
- The Joint Force Air Component Commander (JFACC) tasks theater UAS assets, including the Predator and Global Hawk, against specific ISR requests. The JFACC has had limited visibility into the use of UAS ISR assets controlled by tactical units. That limitation can lead to duplicative taskings as well as diminish the commander’s ability to fully leverage all available assets.

Performance Evaluation

- DOD uses limited quantitative metrics to measure the effectiveness of its ISR missions, and it does not routinely capture feedback on ISR effectiveness in meeting warfighters' requirements.

- DOD components, such as JFCC-ISR, have been tasked with developing ISR performance metrics. While they have made some progress, they have not set milestones for completing this effort.

- Without developing metrics and systematically gathering feedback, DOD is not in a sound position to validate the true demand for its ISR assets, determine whether it is allocating and tasking these assets in the most effective manner, or acquire new systems that best support its warfighting needs.

General Observations on UAS Acquisitions

- More joint investment strategy based on portfolio management principles needed
- Improved business case development and lower risk acquisition strategies
- More effective systems engineering practices need to be followed
- Better cost and schedule outcomes

Opportunities Exist For Greater Collaboration Across UAS Programs

- Greater collaboration on similar programs but different services would create a more efficient and affordable approach
  - Army and Navy's collaboration on Fire Scout has achieved benefits
  - BAMS could benefit from greater collaboration
  - Warrior and Predator have been slow to exploit synergies

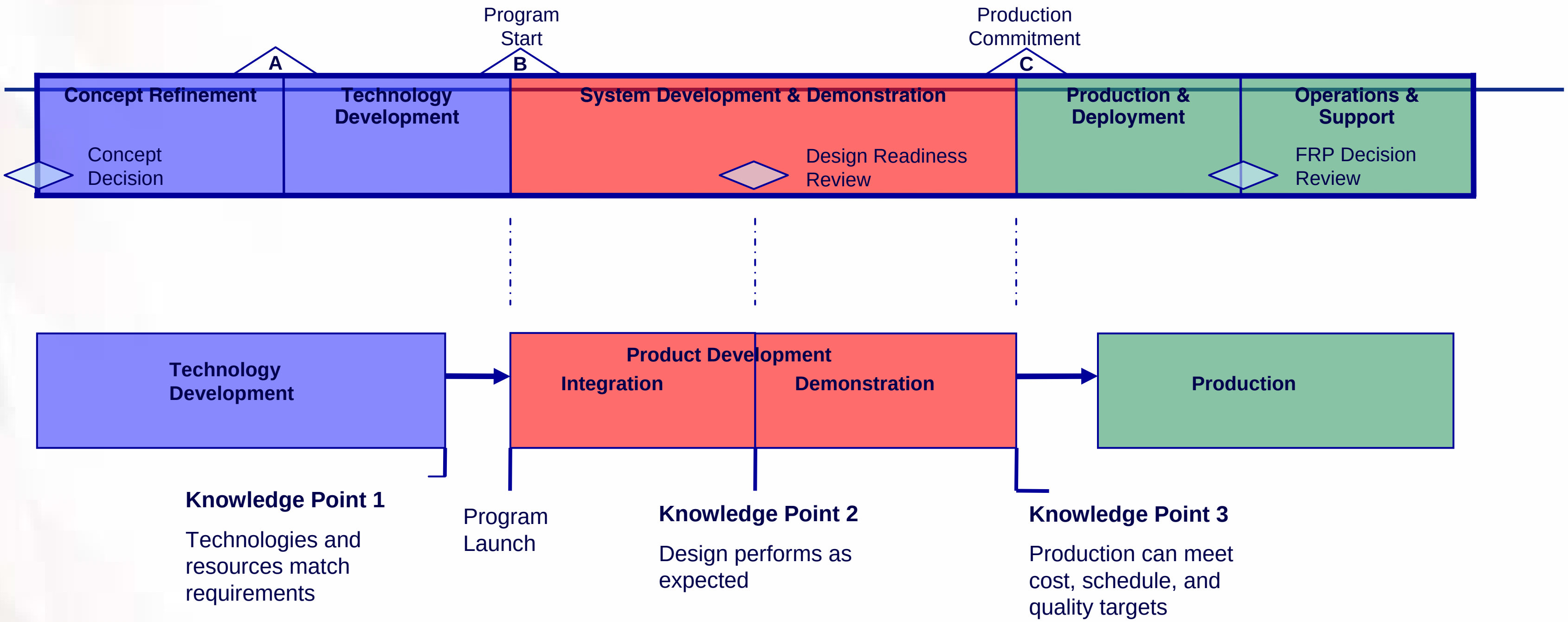
UAS Are Not Immune to Common Development Problems

- Immature technologies
- Requirement changes
- Design changes
- Quality and reliability problems

Examples of UAS Programs, Problems Encountered, and Impact

System	Problem Encountered	Impact
Global Hawk	•Concurrent acquisition strategy •Immature technology •Requirements changes •Design changes	•Development cost growth of 261 percent •Schedule delay of 36 months •Several program restructures •Increased investment in legacy systems
MQ-9 Reaper	•Concurrent acquisition strategy •Immature technology	• Development cost growth of 13 percent • Schedule delay of 7 months
Warrior	•Concurrent acquisition strategy •Immature technology	•Development cost growth of 21 percent •Schedule delay of 9 months
Broad Area Maritime Surveillance	•Immature technology •Funding availability	•Schedule delayed 39 months

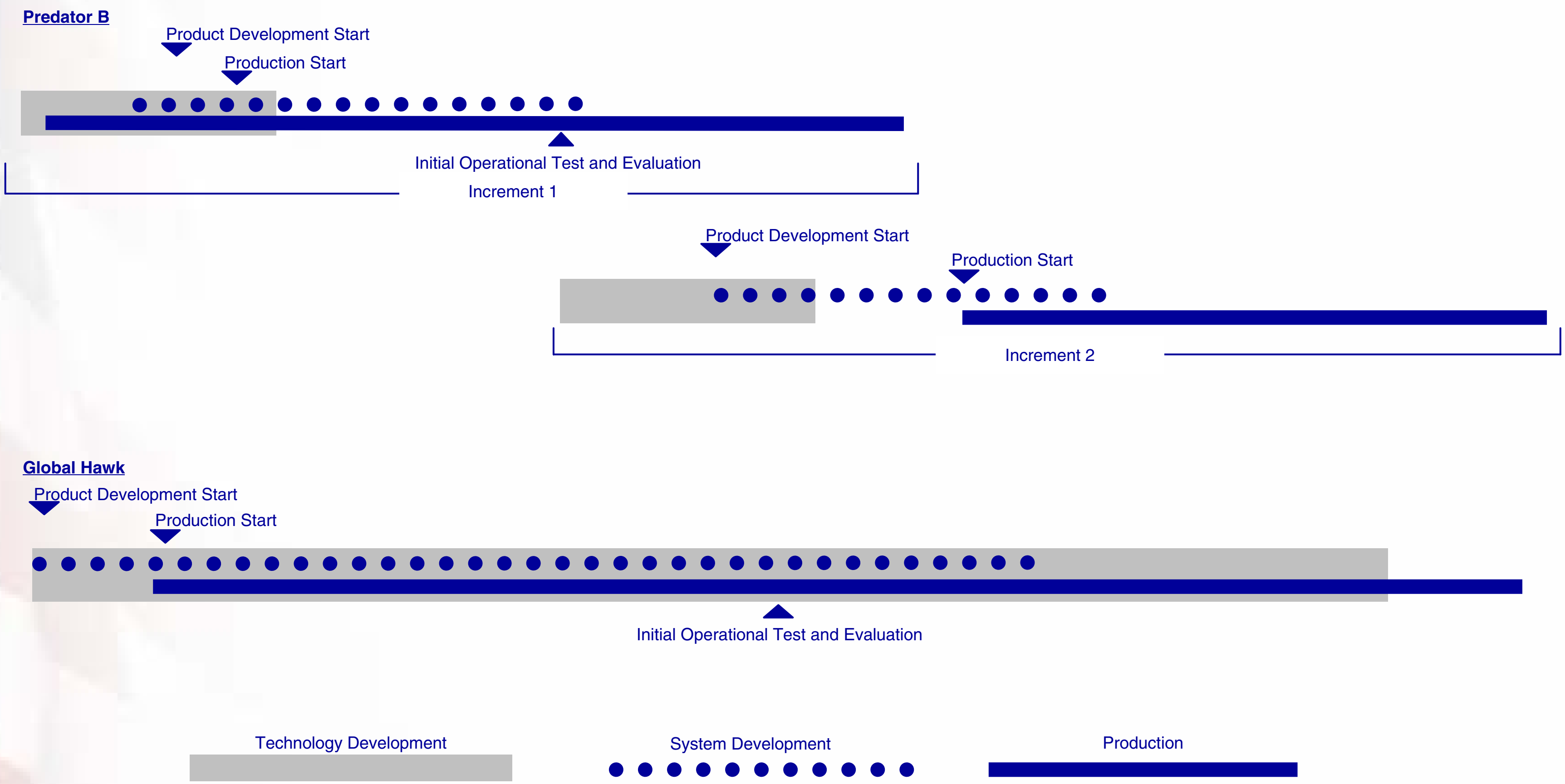
DOD Acquisition Process and Best Practices



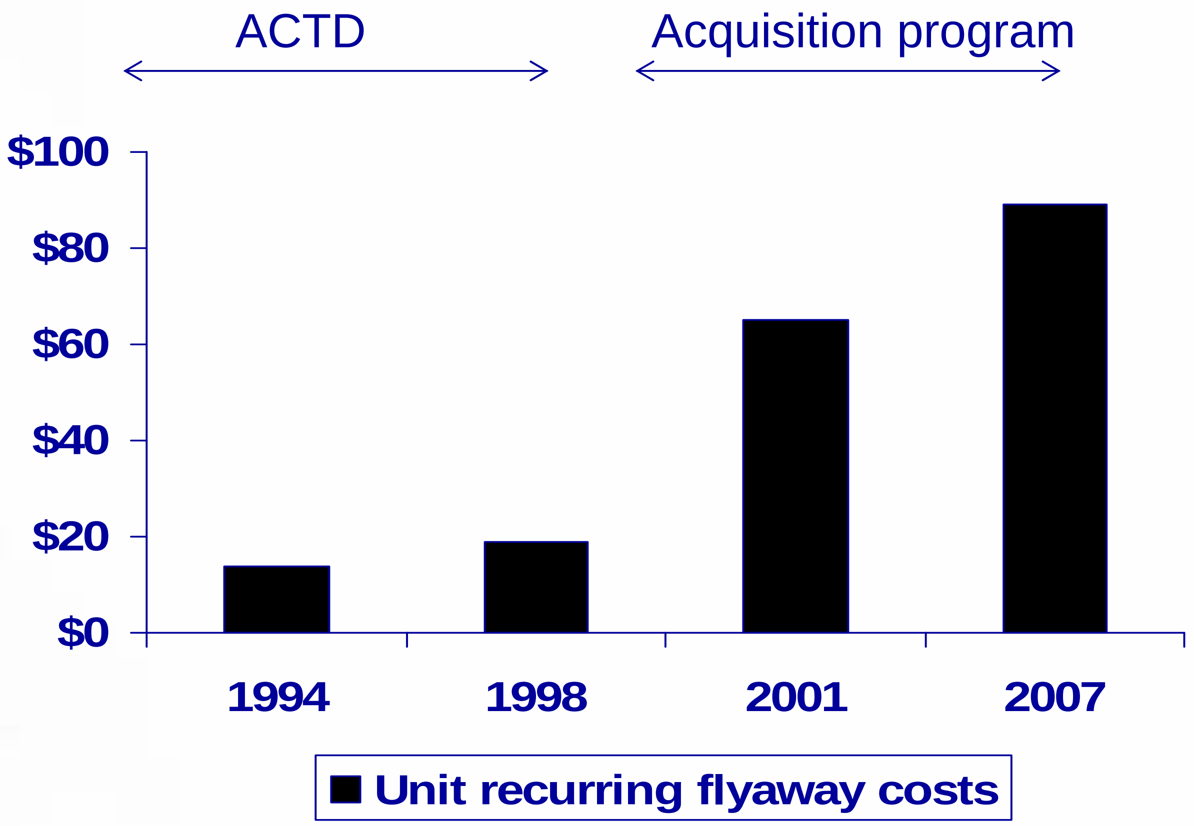
Key pre-system development markers:
--Integrated portfolio management strategy
--Systems Engineering/Requirements Analysis
--Technology maturation and transition

Key development markers:
--Sound, executable business case
--Evolutionary approach
--Knowledge based decision points

Comparison of Predator B and Global Hawk Acquisition Plans



Example of Global Hawk Unit Cost Growth



Related GAO Products

- *Unmanned Aircraft Systems: Advanced Coordination and Increased Visibility Needed to Optimize Capabilities,* GAO-07-836 (Washington, D.C.: July 11, 2007).
- *Intelligence, Surveillance, and Reconnaissance: Preliminary Observations on DOD's Approach to Managing Requirements for New Systems, Existing Assets, and Systems Development,* GAO-07-596T (Washington, D.C.: April 19, 2007).
- *Defense Acquisitions: Greater Synergies Possible for DOD's Intelligence, Surveillance, and Reconnaissance Systems,* GAO-07-578 (Washington, D.C.: May 17, 2007).
- *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-07-406SP (Washington, D.C.: March 30, 2007).
- *Best Practices: An Integrated Portfolio Management Approach to Weapon System Investments Could Improve DOD's Acquisition Outcomes*, GAO-07-388 (Washington, D.C.: March 30, 2007).
- *Unmanned Aircraft Systems: Improved Planning and Acquisition Strategies Can Help Address Operational Challenges,* GAO-06-610T (Washington, D.C.: April 6, 2006).

Related GAO Products (continued)

- *Unmanned Aircraft Systems: New DOD Programs Can Learn from Past Efforts to Craft Better and Less Risky Acquisition Strategies*, GAO-06-447 (Washington, D.C.: March 15, 2006).
- *Unmanned Aircraft Systems: Global Hawk Cost Increase Understated in Nunn-McCurdy Report*, GAO-06-222R (Washington, D.C.: December 15, 2005).
- *Unmanned Aircraft Systems: DOD Needs to More Effectively Promote Interoperability and Improve Performance Assessments,* GAO-06-49 (Washington, D.C.: December 13, 2005).
- *Unmanned Aerial Vehicles: Improved Strategic and Acquisition Planning Can Help Address Emerging Challenges,* GAO-05-395T (Washington, D.C.: March 9, 2005).
- *Unmanned Aircraft Systems: Changes in Global Hawk's Acquisition Strategy Are Needed to Reduce Program Risks*, GAO-05-6 (Washington, D.C.: November 5, 2004).

GAO Contact Information

Sharon L. Pickup
Director, Defense Capabilities and Management
U.S. Government Accountability Office
pickups@gao.gov or (202) 512-9619

Michael J. Sullivan
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
sullivanm@gao.gov or (202) 512-4841

NDIA
National Test & Evaluation Conference

Unmanned Vehicle Synthetic Environment

February 26, 2008

Angelo Prevete
Program Manager
Lockheed Martin
Simulation, Training & Support

Tel: 407-306-5019

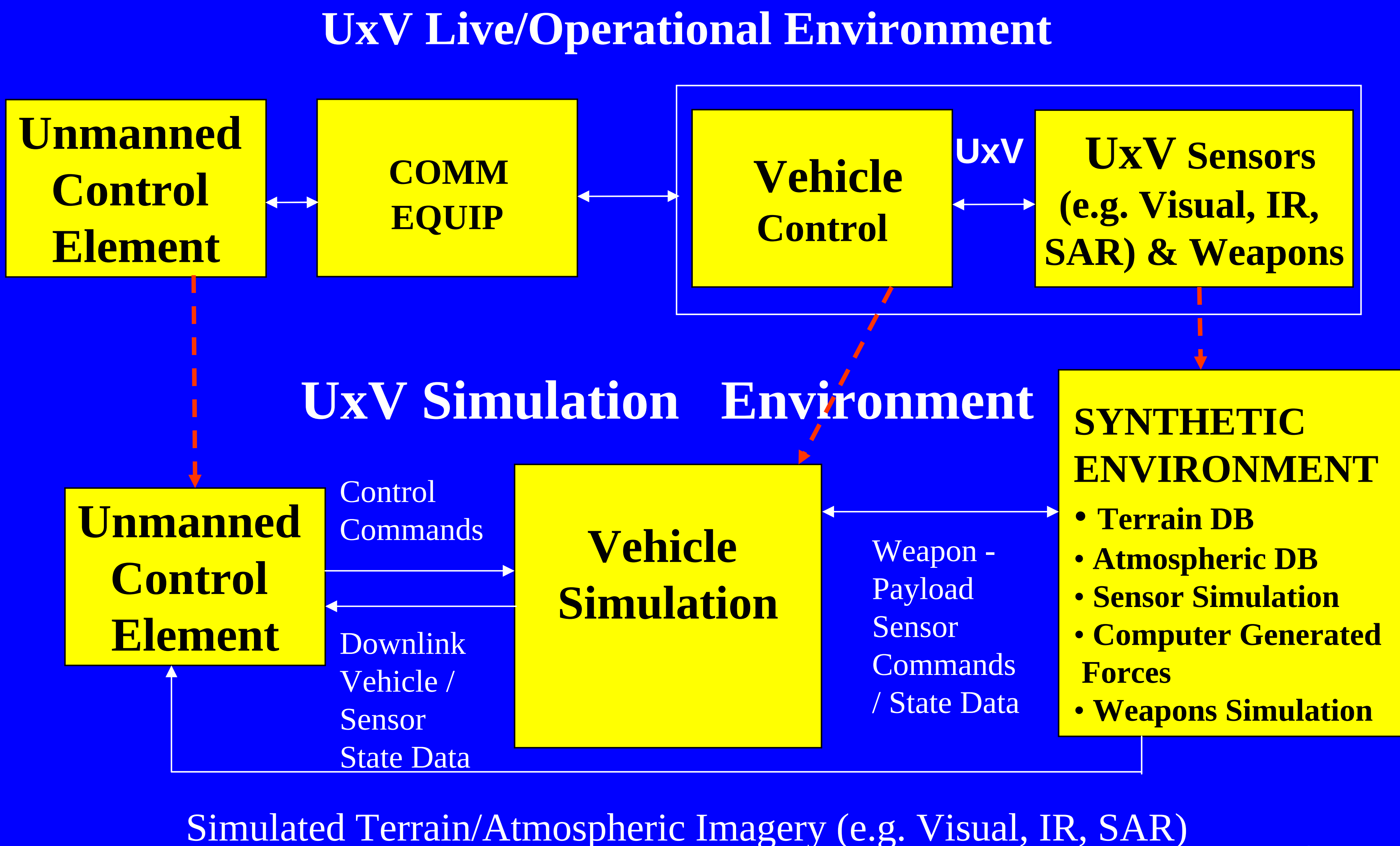
Myron Mills
Project Manager
Lockheed Martin
Missiles & Fire Control
Combat Maneuver Systems

Tel: 972-603-7786

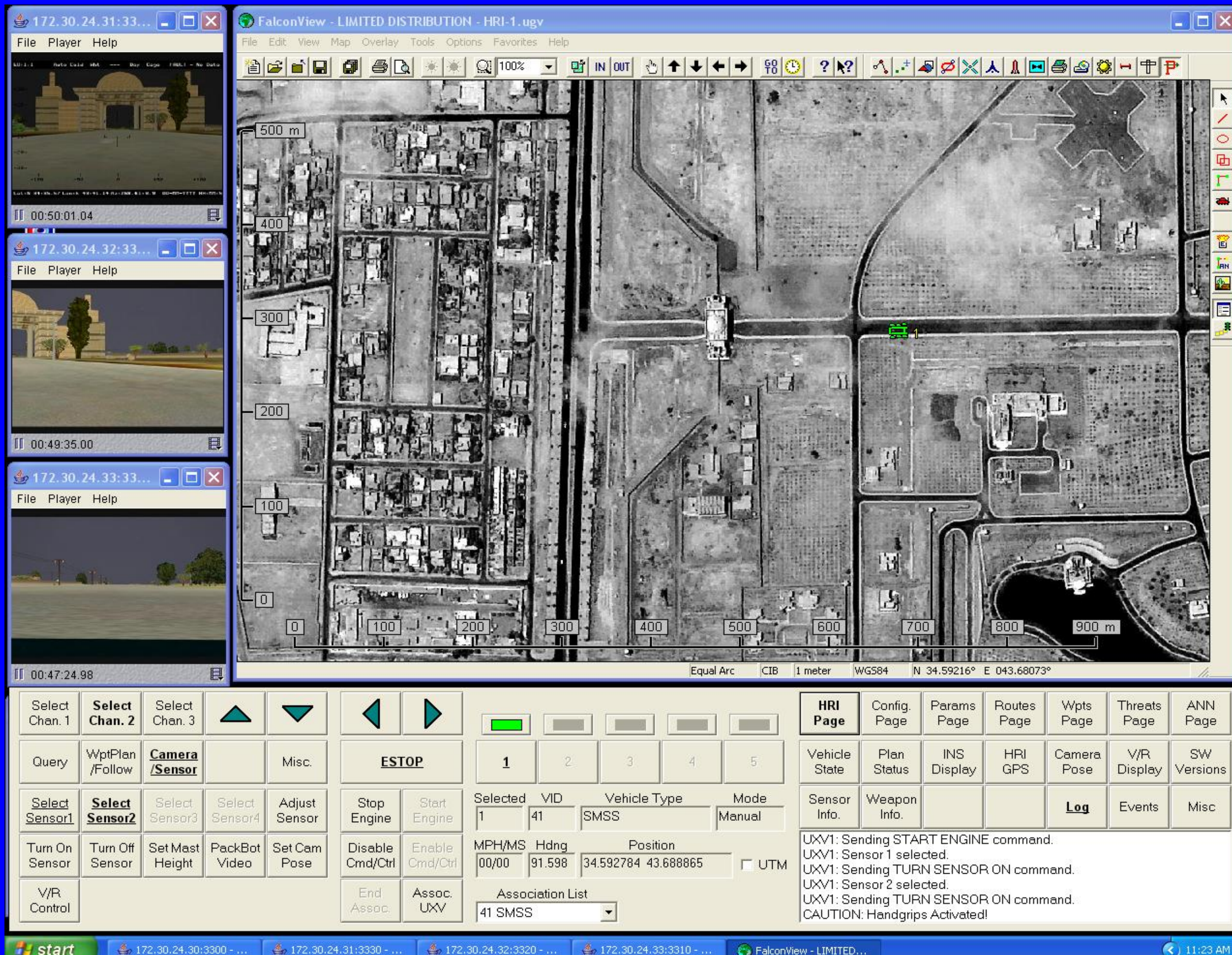
Introduction

- **Description of an Unmanned Synthetic Environment**
  - **Operational vs. Simulation Architecture**
- **Example Control Elements**
- **Video Examples of Real-time Sensor Images**
- **When a UxV Synthetic Environment (SE) could be used**
- **Corporate Research and Development Efforts**
  - **Unmanned Ground Vehicle Technology Transformation Program (TTP)**
  - **Fast Inshore Attack Craft (TTP)**
- **Conclusion**

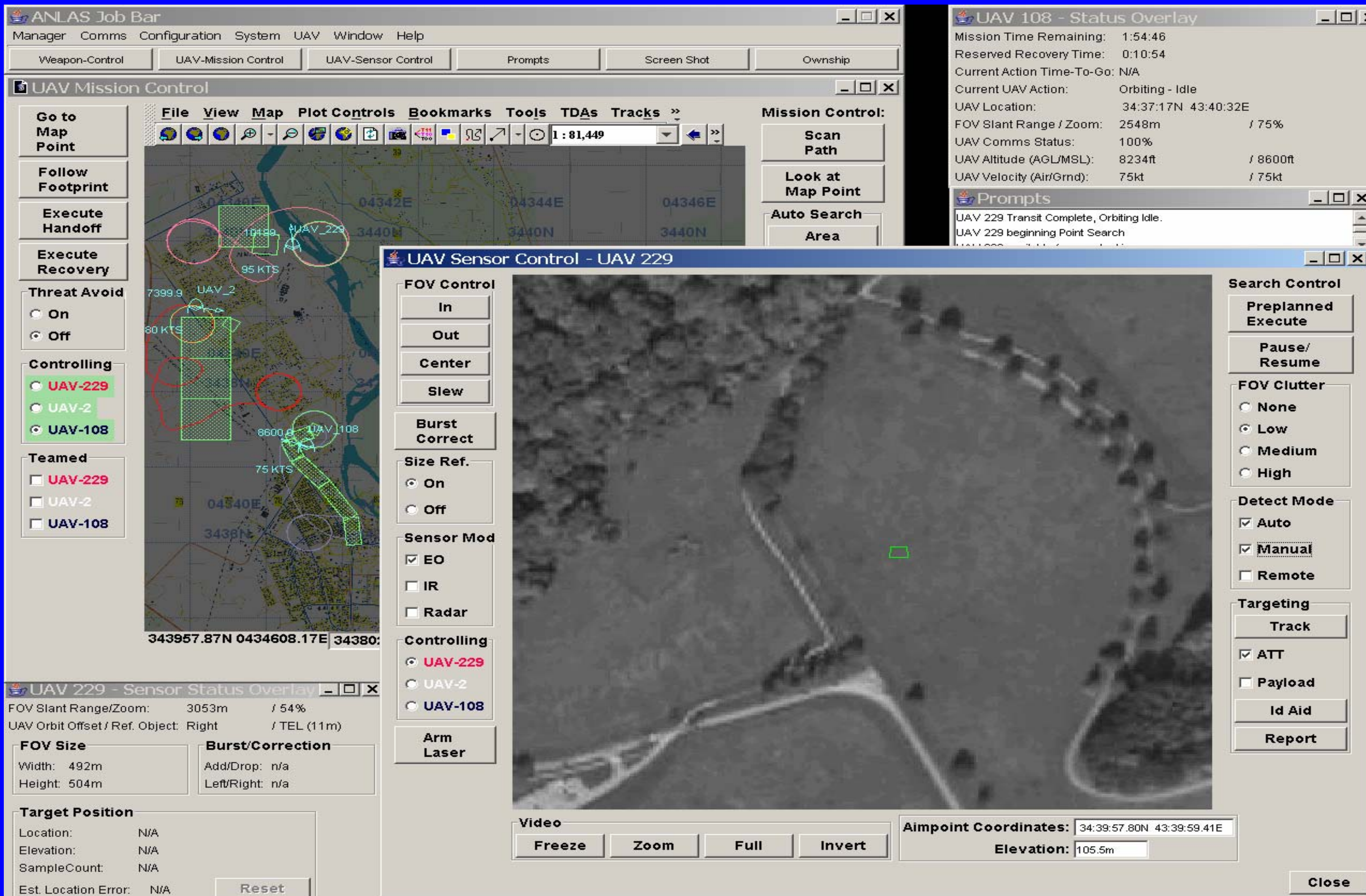
UxV Architectures



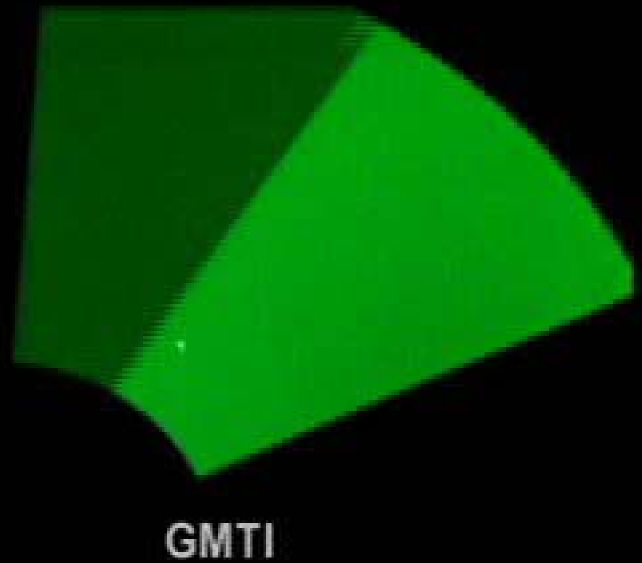
Example Control Element: Universal Controller Prototype (UCP)



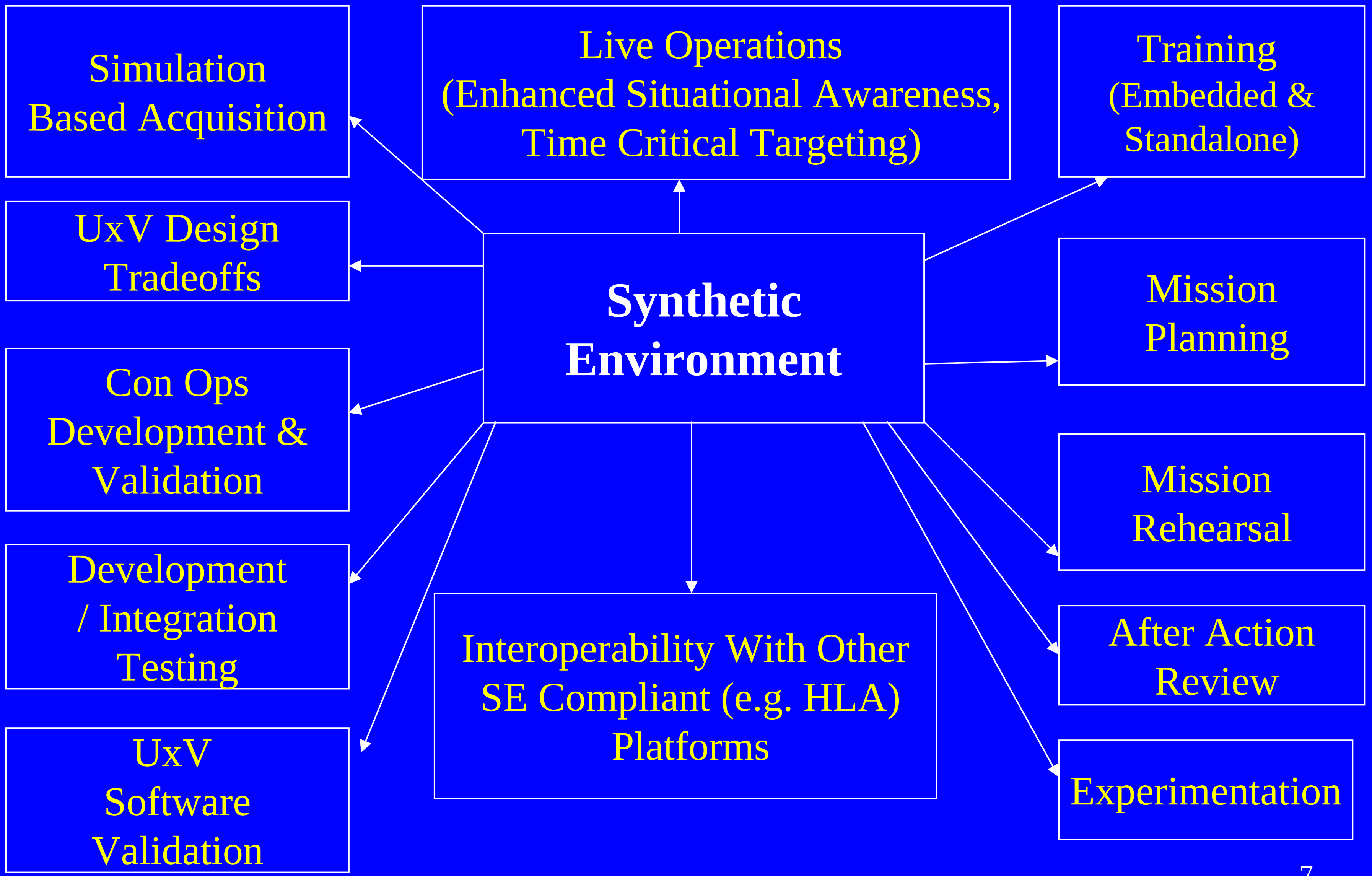
Example Control Element:
Generic Unmanned-Vehicle Supervisory Segment (GUSS)



Video Example of UxV Sensor Simulation



When a UxV Synthetic Environment (SE) could be Used



Corporate IR&Ds

Unmanned Ground Vehicle Technology Transformation Program (TTP)

Objectives:

- Develop an Unmanned Vehicle (UxV) Simulation Test-bed to evaluate the impact of unmanned systems on combat effectiveness, lethality and survivability of the platoon
- Provide Tool for deriving unmanned systems requirements, CONOPS, and Tactics Techniques and Procedures
- Simulate a Light Infantry Platoon conducting operations in complex urban scenarios

Key ideas to examine:

- "Rules"/Logic For Multi-vehicle/Multi-controller Use
- Autonomy, Situation Awareness, Collaboration & Role De-confliction
- Control Hand-off At The Unit Level
- Element "Out Of Fight" Taking control Of Unmanned Systems

Synthetic Environment Includes:

- 4 Simulated Video Channels: Multi-vehicle, Dynamically Selectable
- "Build-a-Bot", Scalable, Unmanned Vehicle Simulation (UGV and VTOL UAV)
- Universal Controller Prototype with simultaneous control of multiple types of UxVs
- Joint Semi-Automated Forces (JSAF) for Manned Ground Vehicle and Dismounted Infantry Simulation

Unmanned Vehicle (UxV) Simulation Test-bed

Demonstration System Layout

Unmanned Vehicle (UxV) Simulation Test-bed

Controller and Stealth Displays

Unmanned Vehicles (UxV) Simulation Test-bed

Live Vehicle Static Displays

Unmanned Vehicle (UxV) Simulation Test-bed

Live Vehicle Static Displays

Unmanned Vehicle (UxV) Simulation Test-bed

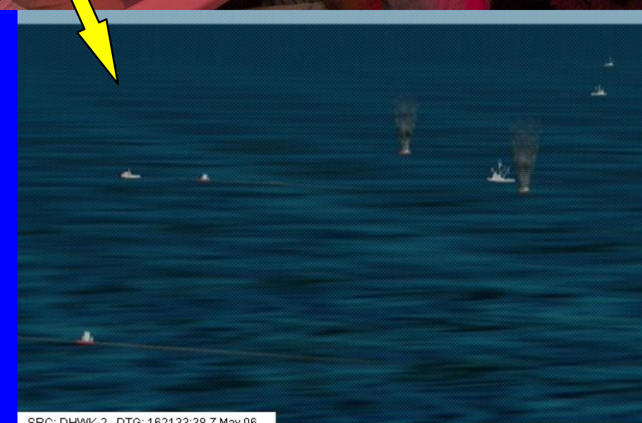
Customer Demonstrations

Corporate IR&Ds (Cont)

Fast Inshore Attack Craft (FIAC) TTP

- Experimental platform used to demonstrate ship protection within 5 NM radius
- Uses LM Sea Slice vessel, Hellfire Missiles, Radar, EO/IR sensors and UAVs
- Live and simulated experiment performed on Sea Slice vessel operating in vicinity of Channel Islands and San Diego
- Synthetic Environment includes:
    - Embedded simulation capability – 10 simulated video channels
    - Santa Cruz / Santa Rosa Channel Islands / San Diego coastline DBs for exercise area
    - Radar Track and sensor simulation provided to onboard C4I devices
    - Hellfire simulation
    - Joint Semi-Automated Forces (JSAF) used to generate naval insurgent attack scenarios

Operational Simulation & Visualization



Simulation Capabilities

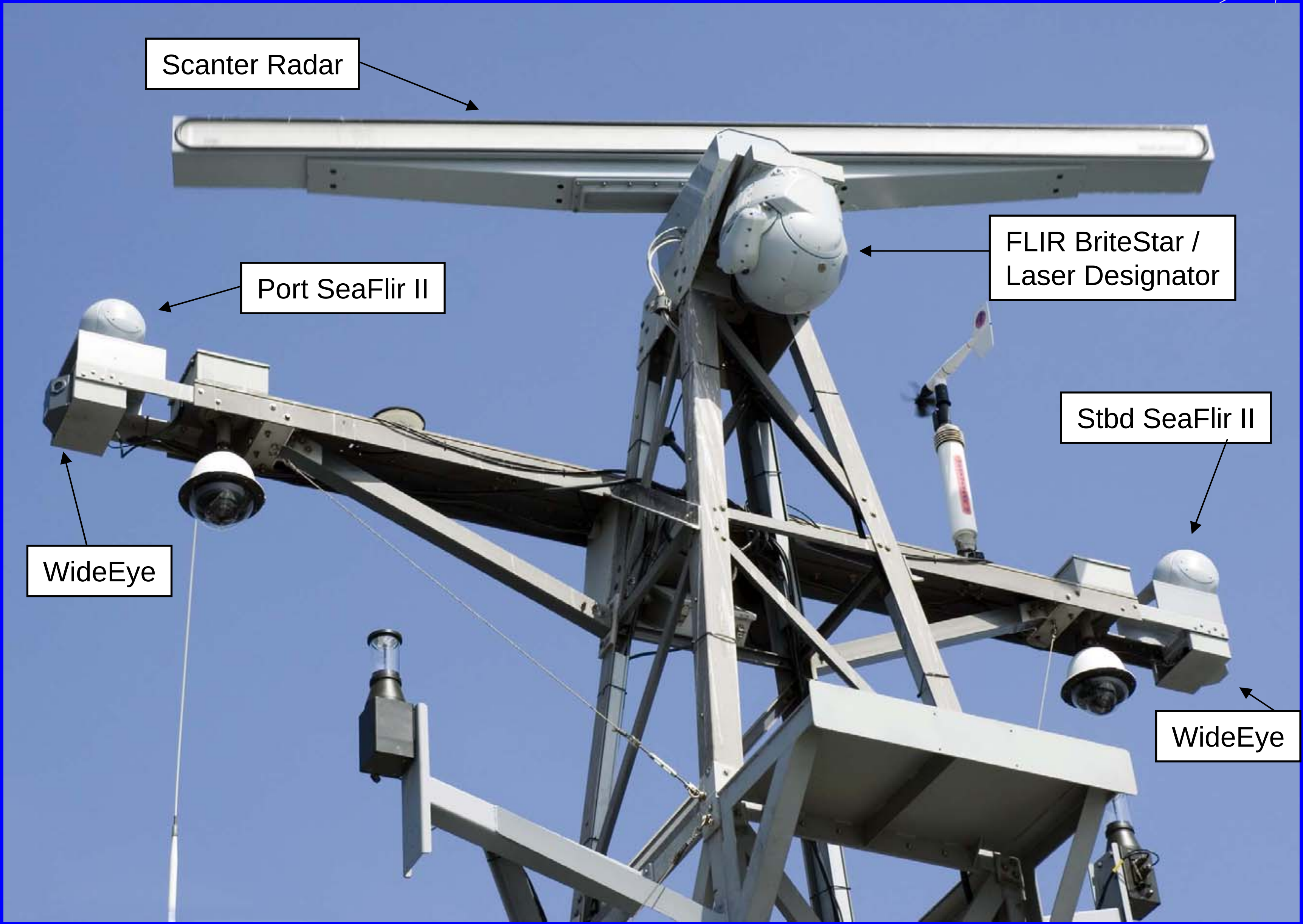
- Full Fidelity Synthetic Environment
  - Natural representation of geo-specific operating areas
- Robust Semi-Automated Computer Generated Forces (CGF)
  - Hostile target boats, friendly and neutral clutter
  - Scenario Generation functionality
- Real-time Sensor Simulation
  - EO, IR, and Radar simulation at Combat Management Operator stations
- Realistic Weapons Engagement
  - Hellfire fly-out and engagement of CGF
- Embedded in Tactical Systems
  - Distributed environment driving situational awareness at each operator station

Operational Value

- Initial Team Training through Mission Rehearsal
- Concept Development and Experimentation
- Tactics and Doctrine Development

Sea Slice Dockside

Sea Slice Mast Sensors



Simulated Attack

UAV Capture

Hellfire Launch Pedestal

Conclusion

- Transparency in HMI operations whether performing live or in simulation is the goal
- Embedded simulation provides extremely cost effective method to maintain team readiness
  - Required only 15 minutes on Sea Slice to transition from simulated to live operations
  - Enables disparate C4I devices to operate collectively on same Training and Mission Rehearsal scenarios
- A representative suite of equipment incorporating the described capabilities has been brought to the conference. The UxV configuration is available for demonstration and further discussion in the NDIA Display area. Please feel free to stop by.

Joint Ground Robotics Enterprise

Ground Robotics Test and Evaluation: Are We Ready?

Presented at National Industrial Defense Association

27 February 2008

Mrs. Ellen M. Purdy
Enterprise Director, Joint Ground Robotics
OUSD(ATL)/PSA/LW&M
ellen.purdy@osd.mil

Agenda

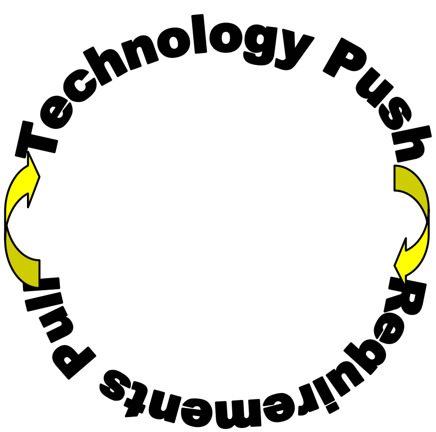
- If Past is Prologue…..Then Robotics are 'Coming to a Theater Near You'
- Where are We Headed? (and Are We Ready?)
- Thoughts on What is Needed to be Ready to Test
- Hopeful Signs of Progress
- Conclusions

Ground Robots
Proving Their Worth…

Vietnam
- Four Decades Ago -

Afghanistan
- Four Years Ago -

Iraq
- Today -



Joint Robotics Program

Joint Ground Robotics Enterprise

Progress in Autonomy and Cognition

Million instructions/ second

1B

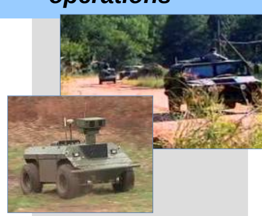
10M

100K

1K

Key Challenges

- High speed mobility
  - Improved perception
  - Reliable data fusion
- Safe operations
  - Detect & classify stationary people & objects
  - Collision avoidance
- Design for tactical behavior flexibility
  - Understand environments
  - Decision processing
  - React appropriately to contact
- Collaboration
  - Conduct collaborative missions with mixed manned/unmanned force
  - Collaborative air-ground operations



Demo IIIa

Air/Ground Collaboration

Crusher/DARPA

True follower—follows in tracks of manned leader

On-road convoy operations

Armed Reconnaissance Vehicle—RSTA

Near autonomous team members

1999 2005 2008 2011 2015…

Ground Robotics are Saving Lives, But How Do We Test to Avoid:

- The first robot to injure a human in testing?
- The first robot to be captured and turned on US troops?
- The first robotic friendly fire incident?

What's on the Horizon?

Snakebot

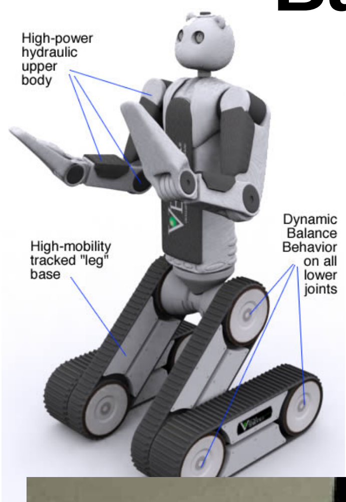
- Provides the ability to navigate over rough, steep terrain where a wheeled robotic
vehicle would likely get stuck or topple over

- Recon in severely restricted terrain

- Future software will allow the Snakebot to learn on its own by experience

What's on the Horizon?

Battlefield Extraction-Assist Robot (BEAR)



- Currently in the proof-of-concept development phase for US Army's Telemedicine and Advanced technology Research Center
- Designed to find, pick up and rescue people without risking additional human life
- Upper body controlled by hydraulics
- A mobility platform that features two independent sets of tracked "legs"
- Features dynamic balancing behavior (DBB) while on its "ankles", "knees" or "hips"

What’s on the Horizon?

Little Dog

Big Dog

- Developed under the Defense Advanced Research Projects Agency’s (DARPA) Learning Locomotion program

- Goal is to learn how to traverse large, irregular obstacles with a high degree of freedom robot

- Expected Locomotion Strategy:
    - Develop a library of moves to traverse terrain elements
    - Recognize similar, already learned elements and modify as required in real time
    - Best results will be ported to Big Dog

What's on the Horizon?

• Developed by Carnegie Mellon University to assess the capabilities of large, unmanned ground vehicles operating autonomously in a wide-range of complex, off-road terrains

• Made of high-strength aluminum and titanium to withstand below-hull strikes from boulders and tree stumps, and a nose designed to absorb the impact of major collisions.

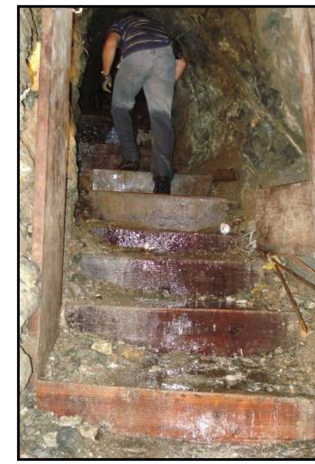
Crusher

Lessons from SWORDS Safety Testing?

- **The SWORDS Spiral 1 was subjected to testing for a total of 1,111 operational hours at Aberdeen Proving Ground**
- **The following design changes were made solely to increase safety. In most cases performance is slightly degraded due to the design change. All design changes were included in the final System Safety testing.**
  - **Increased number of steps in firing sequence**
  - **Limit operation of the system to ranges where the operator can see the vehicle line of sight**
  - **Loss and regain of communications between the OCU and vehicle will cause the operator to re-run arming and firing sequence, regardless of ready state prior to communications loss**
  - **Weapon cannot be fired while platform is moving (Weapon firing is inhibited while joystick is engaged to move vehicle)**
  - **Vehicle "Kill Switch" added**

Thoughts on What May Be Needed to Test Successfully…

- **Performance adjudication: wheels, tracks, legs, snake motion…which one more operationally effective?**



- **Definition of levels of autonomy and standard performance metrics for each…how do you verify that you have achieved the desired level of autonomy?**

Thoughts on What May Be Needed to Test Successfully…

- Safety Releases- Are we ready for armed autonomous robots (e.g. SWORDs limitations)?
- The TRUST Factor- If humans do not trust robot to perform, then inherent capability may not be achieved…how do we measure?

Test Standards and Instrumentation

- E-Stops, data logging, position
- How much latency is too much?

- Standard Test Methods, Metrics

Effective Tests

Computer vision may not be as good as thought, according to MIT study

Cathryn M. Delude, McGovern Institute
January 24, 2008

- Apparent success may be misleading because the tests being used are inadvertently stacked in favor of computers

- Caltech101 database, intended to test computer vision algorithms against the variety of images seen in the real world

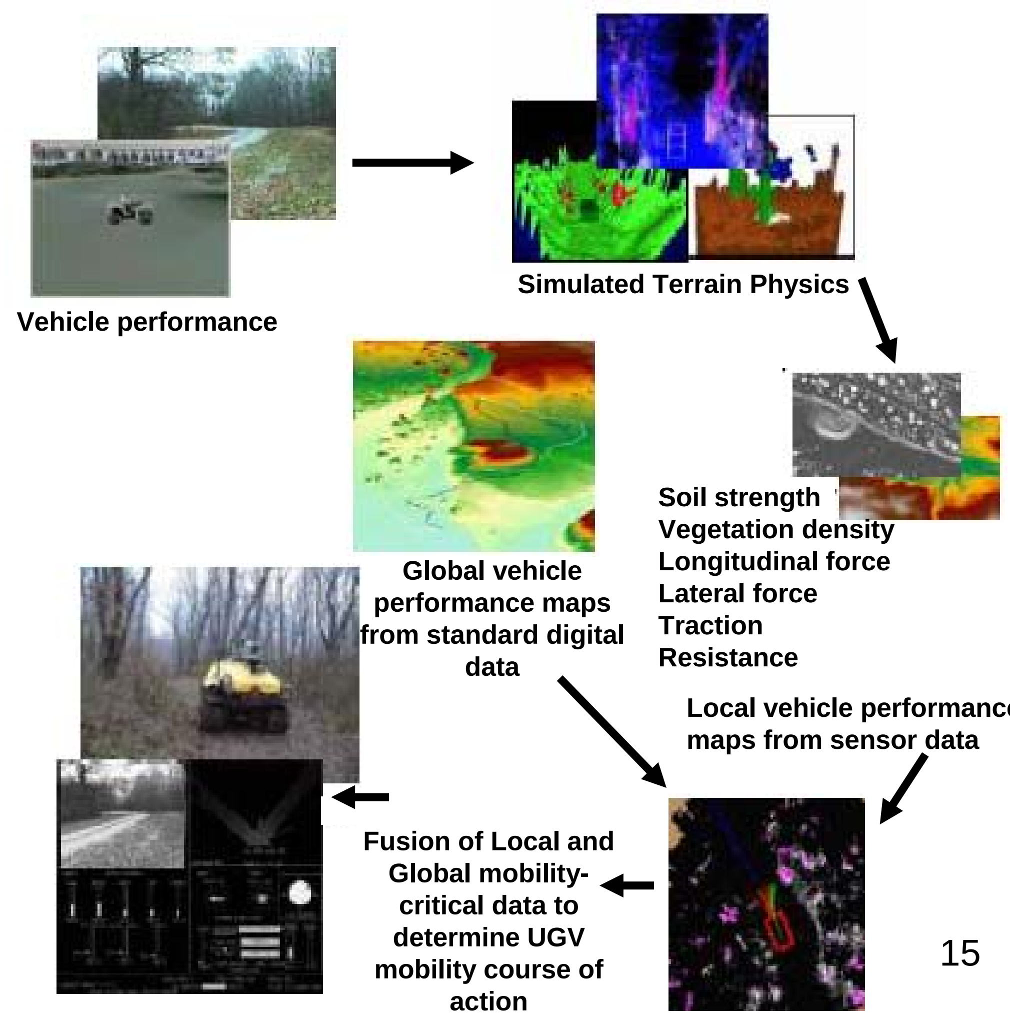
- Caltech101 'natural' images fail to adequately capture real-world variability

The human brain easily recognizes that these cars are all the same object, but the variations in the car's size, orientation and position are a challenge for computer-vision algorithms. Image / Nicolas Pinto

One Possible Answer

Virtual Autonomous Navigation Environment (VANE) – Testbed Process

- Provides controlled data for autonomous navigation algorithm development
- Provides a systematic process to investigate fusion of local and global mobility data
- Brings an understanding of how complex environments effect UGV autonomous operations
- Mission planning functions based on sensor perceptions



Conclusions

- **It is not a matter of ‘If’, but ‘When’**
- **The Test Community has work to do to ensure we are ready for the challenges…**
  - TOPS
  - Metrics
  - Infrastructure
  - Modeling & Simulation

One Additional Thought…

Robots are coming to the fight…are we capitalizing on them in supporting our testing, e.g. targets, nodes on the network, etc…

NDIA Autonomous Vehicle Test and Evaluation Conference

Semi-Autonomous Dispenser Transport Vehicle for Undersea Sensors System Integration Test Results and Lessons Learned

25 – 28 February 2008

CDR Joseph Conway USN (Ret.)
Director, Systems Engineering
AMRON

LCDR Pete Reinagel USN (Ret.)
Test & Evaluation, Assistant PM
SYS Technologies

Outline

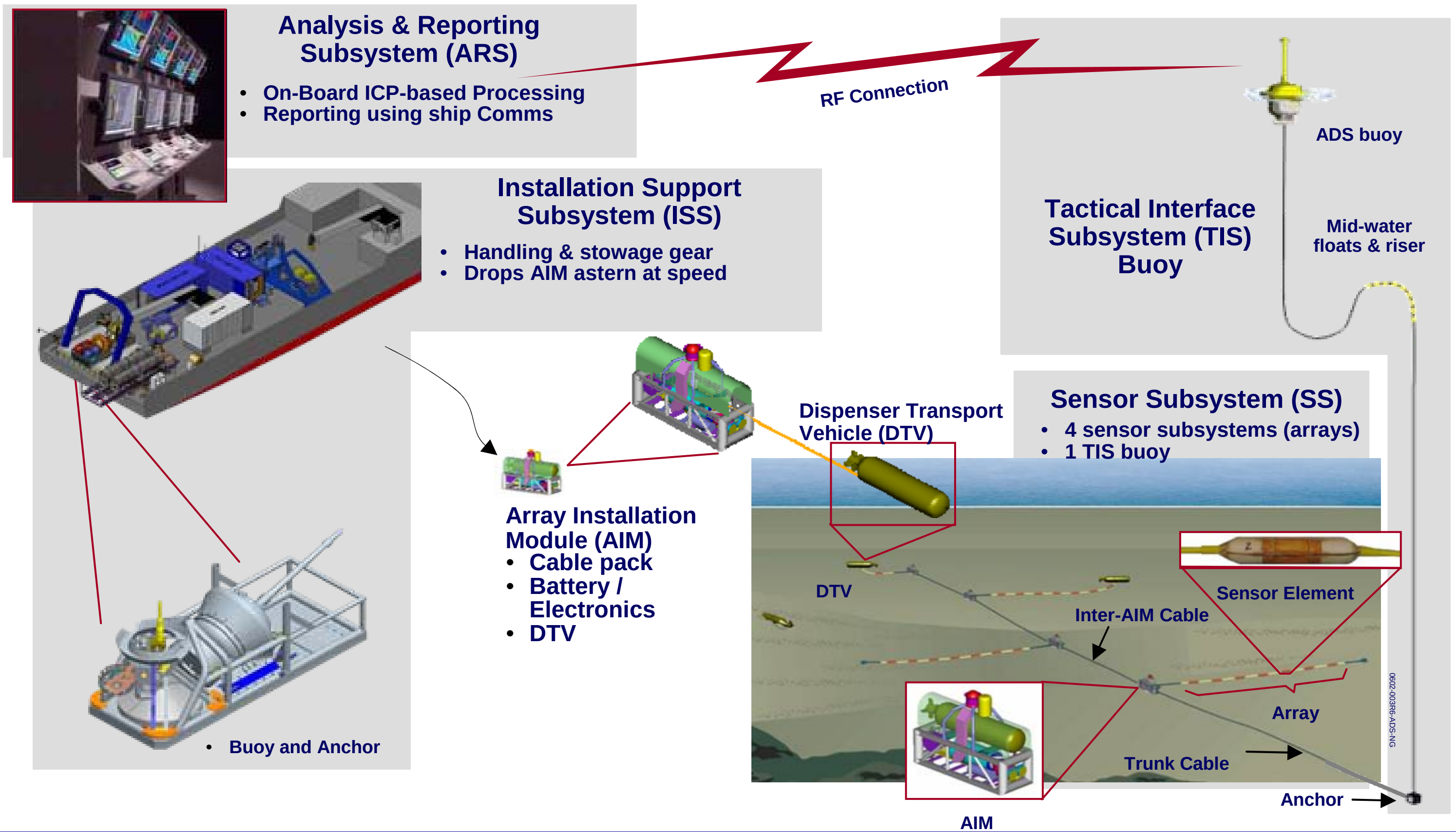
- Introduction
- Background
- Challenges of Delivering Undersea Sensors via LCS
- Development and Characteristics of Dispenser Transport Vehicle (DTV)
- High Level Platform and Design Constraints
- Test and Evaluation
- Lessons Learned and Recommendations

Advanced Deployable System (ADS) Program Overview

- **The primary ADS function is to provide undersea surveillance in shallow littoral waters**
  - ACAT IC POR
  - IOC in 2009
  - Now cancelled
- **ADS program developed multiple semi-autonomous delivery vehicles, known as Dispenser Transport Vehicles (DTV) to install undersea surveillance sensors**
  - Lockheed Martin, Riviera Beach built 8 DTVs in 2007
    - 4 for developmental testing
    - 4 for operational testing

ADS Subsystem Overview

- Purpose: Demonstrate undersea surveillance system for use against enemy submarines in a littoral environment



At Sea Demonstration of Deployable Littoral USW System – Nov 07

ADS System Requirements

- **Detect submarines and surface contacts in the littorals with ability to provide persistent wide area surveillance**
  - Pre-processing in the buoy to reduce bandwidth
  - Contact ID, classification, localization, and tracking done by Fleet STGs on Littoral Combat Ship (LCS)
- **Deployment from LCS – 1st increment**
- **Clandestine delivery – 2nd increment**
- **Array deployment: Semi-autonomous from DTV**
- **Pd: 0.8 – 0.9**
- **Installation time: 4-8 hours / string of 4 arrays + 1 buoy**
- **Installation depth requirement classified**

ADS on LCS CONOPS Overview

- **ADS Mission Module stored in forward deployed area**
- **Module loaded when ordered**
  - Mission Planning was aided by COMUNDERSEASURV
  - The LCS would rapidly go to the Operating Area and install the sensor portion of ADS
    - Rapid installation possible using an AIM – DTV for array placement
  - The LCS with the Analysis and Reporting Subsystem
    - monitored Contacts of Interest and
    - reported to higher authority
  - LCS could be many miles from the sensors and up to 45 miles from the Comms Buoy

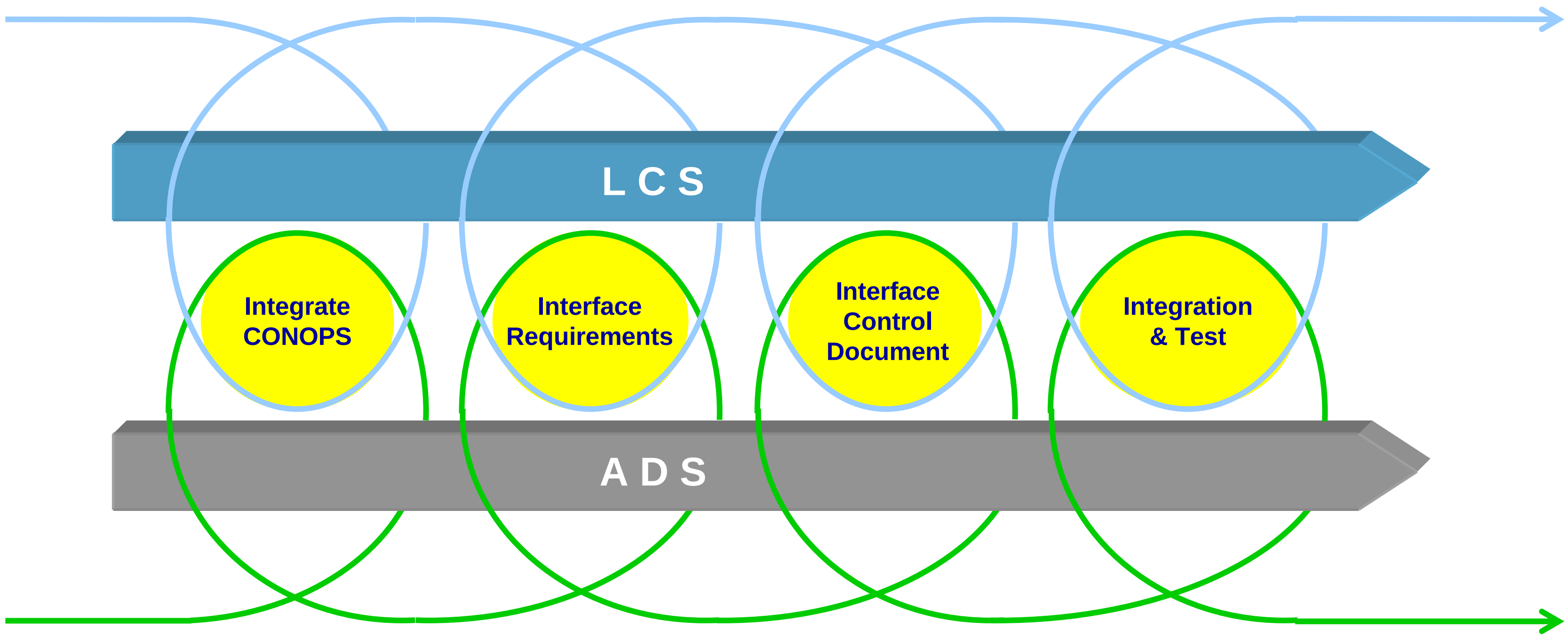
The DTV is vital to making ADS operational.

LCS Program Overview

- Sea Frame handles Mission Modules
- Modules transported to create Mission Packages
- Modules developed to an Interface Control Document
- Floating baseline (hulls differ, storage differ, handling)

Two Sea Frames increased ADS Design Efforts and Risk

Concurrent Spiral Development Touch Points



DTV and Launch & Recovery design were constrained by the selected Delivery Vehicle (LCS) design

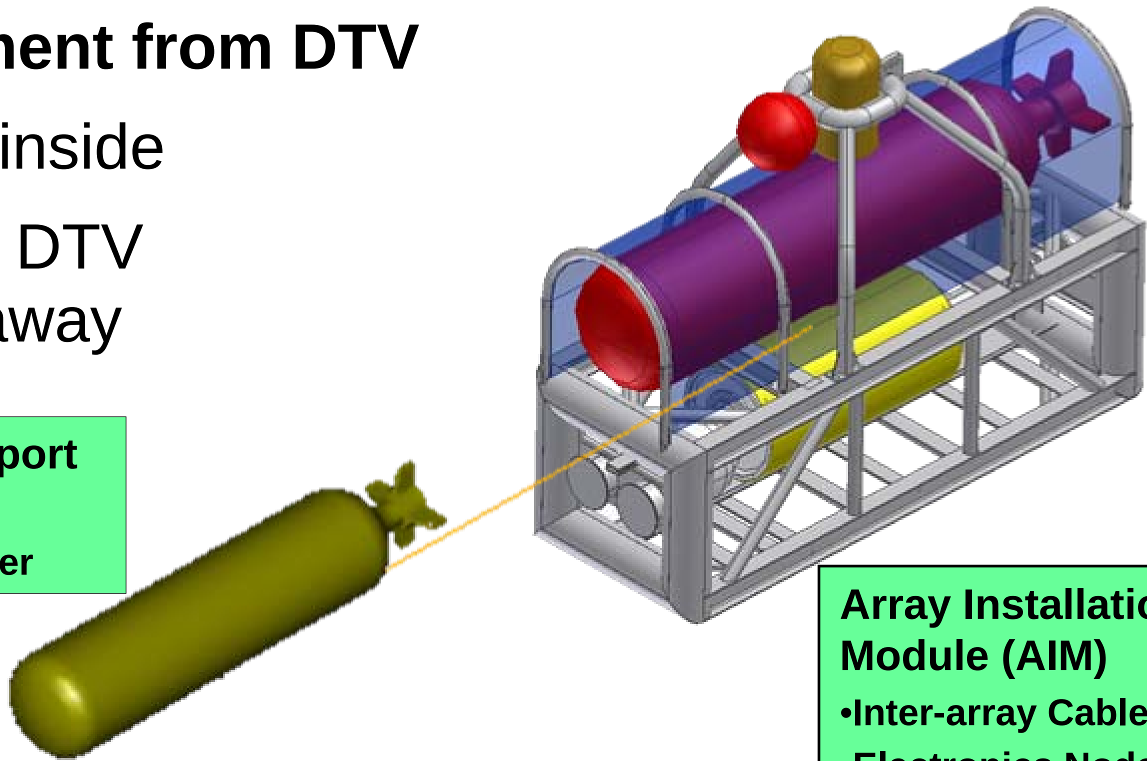
AIM-LCS Interface Development

- **The Array Interface Module (AIM) is the LCS Interface**
  - Design Constraints
    - Mission Bay access and space
    - Ability to maneuver / handle ADS equipment from all stowage locations using shipboard transport equipment
    - Topside and Mission Bay environmental conditions (EMI)
    - Deck Strength
    - Electrical, safety (WSESRB)
    - Size, weight, power of AIM impact on DTV
    - Speed, sea state, height at drop, ice, etc.
    - Staging of DTVs versus NAVSEA 901B Shock requirements

Vehicle Design must consider the Host Vessel

Key Design Characteristics

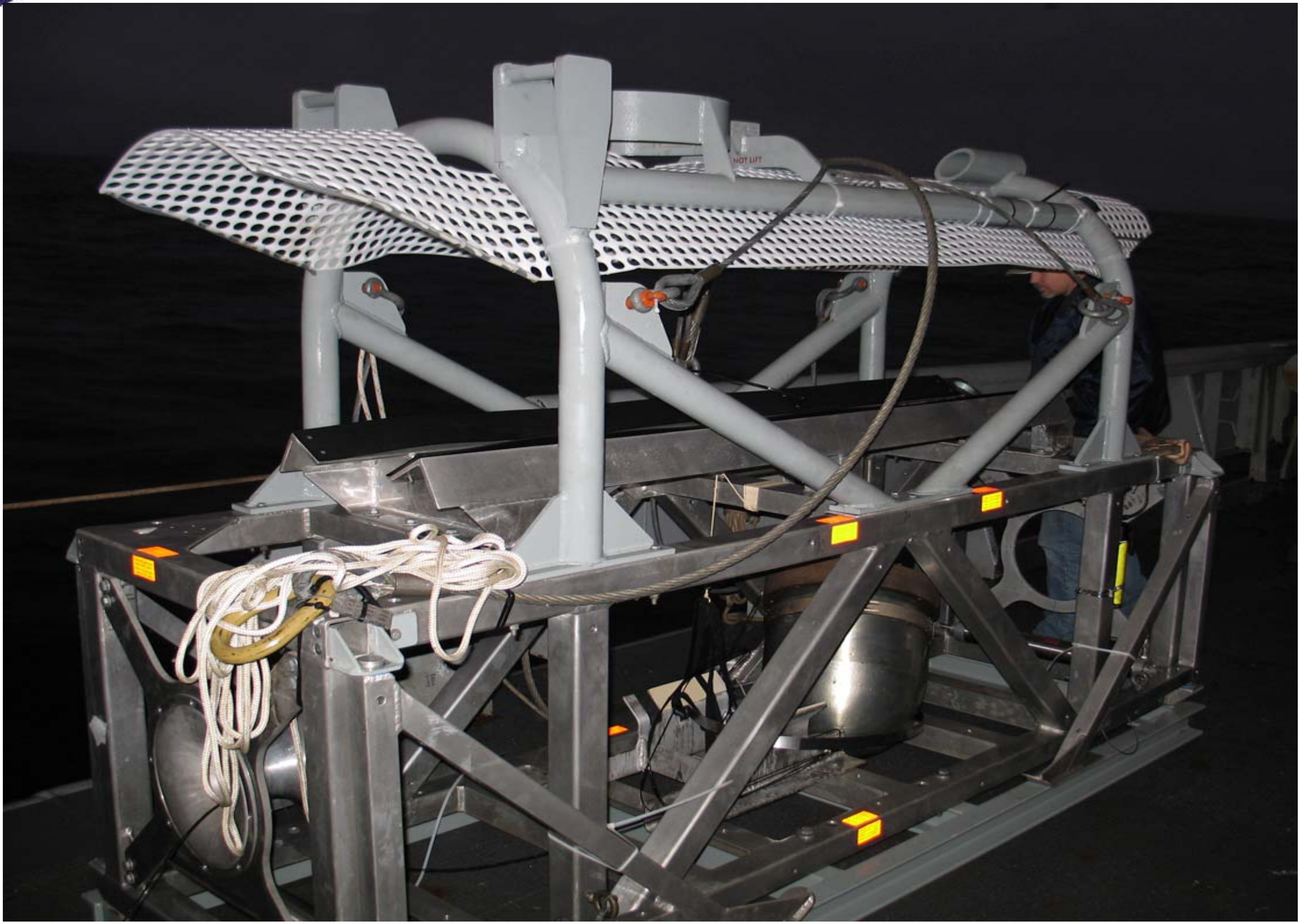
- **AIM has to safely transcend to the ocean floor**
  - Withstanding Shock, Vibration, and Slope
- **Array deployment from DTV**
  - Array coiled inside
  - Pulled out of DTV as it swims away



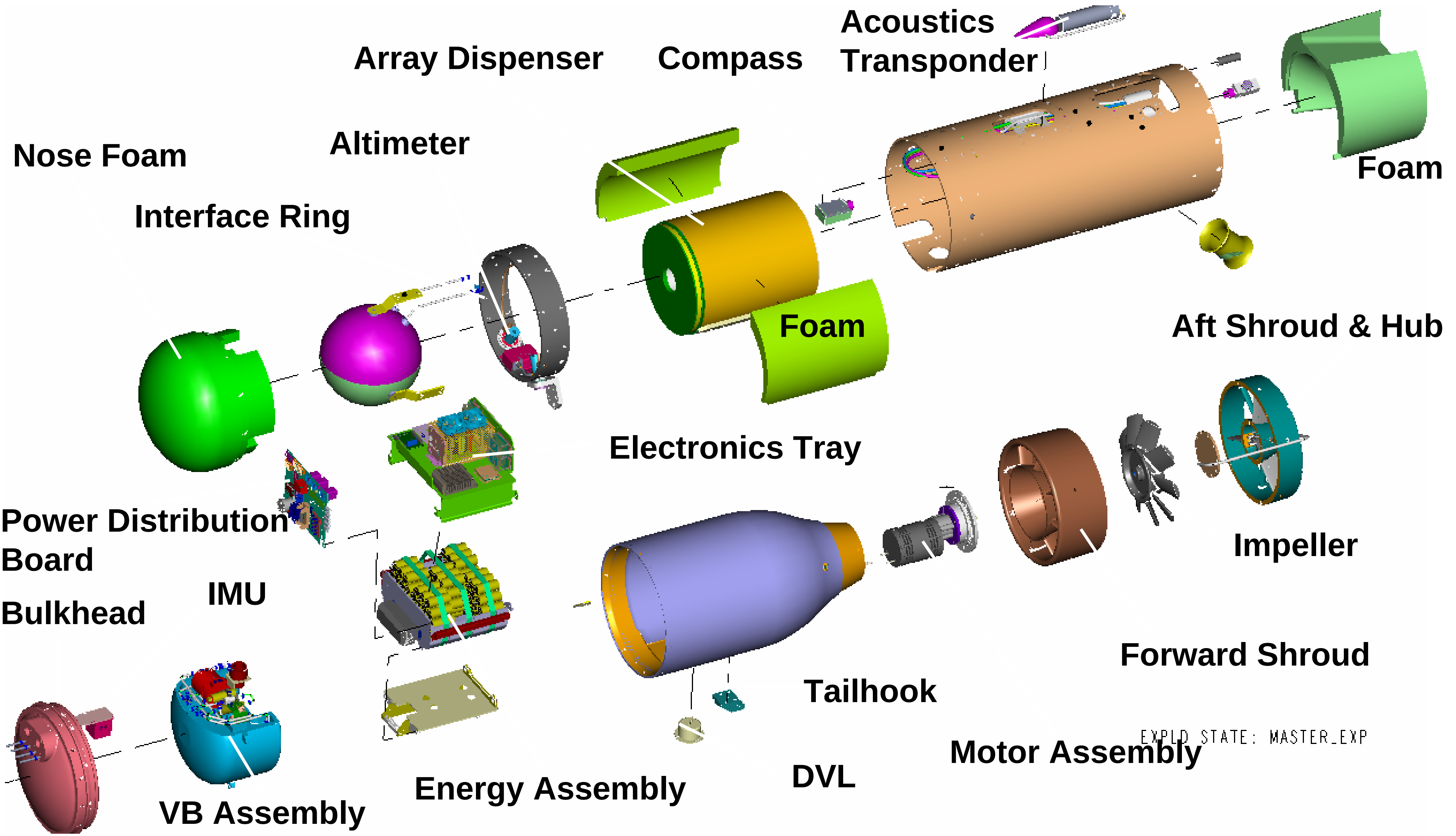
Dispenser Transport Vehicle (DTV)
•Array and dispenser

Array Installation Module (AIM)
•Inter-array Cable Pack
•Electronics Node
•DTV

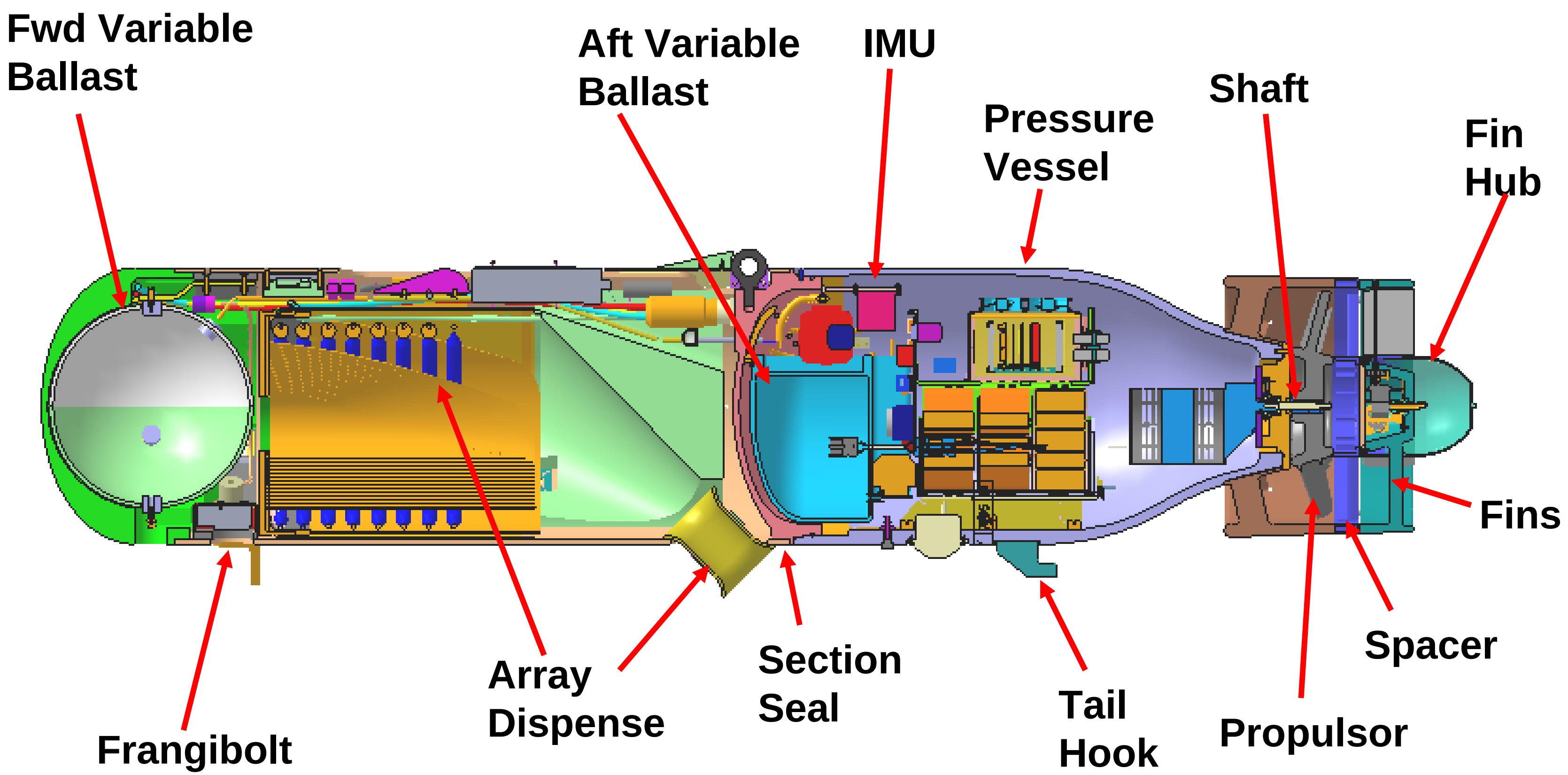
Array Installation Module



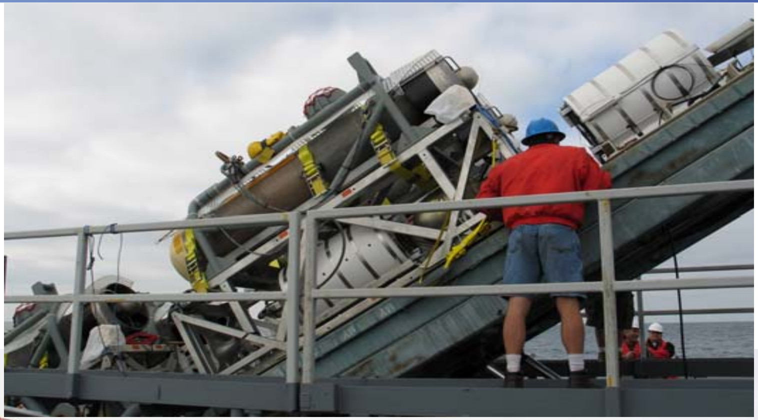
Vehicle Overview



DTV Configuration



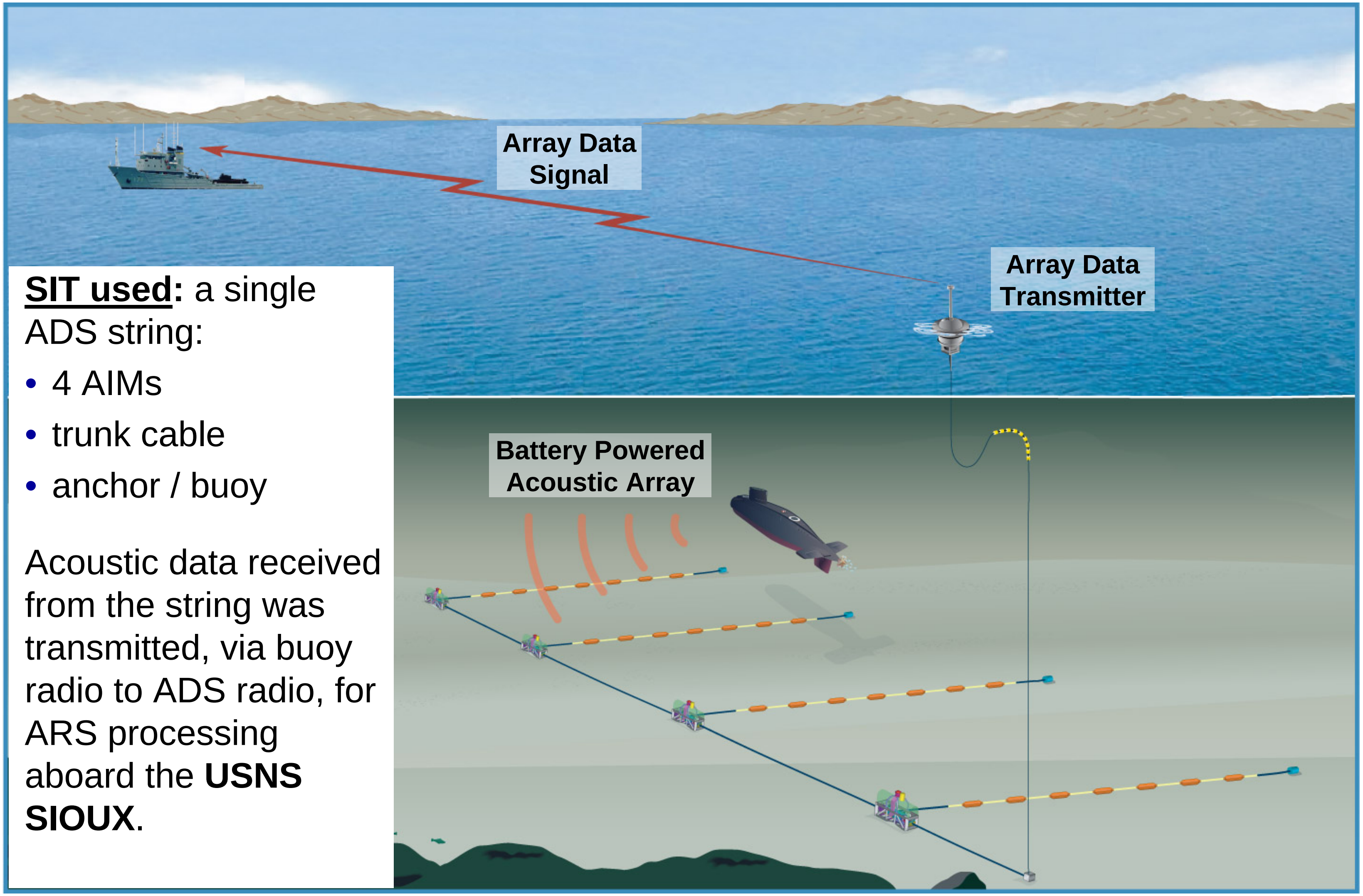
Dispenser Transport Vehicle



Key Developmental Tests

- **Build-up/risk reduction**
  - Modeling & simulation, analysis, and bench testing
- **Ramp test of DTV**
  - Understand shock load and interface
- **Drop test**
  - Verify acceptable shock load
- **Deployment from AIM**
  - Multiple open water tests
- **Control: modeling / at sea demo / re-design**
  - Invaluable contribution of Mr. William Zirke of Penn State
    - Fin spacer and Fin Hub to reduce swirl

System Integration Test (SIT) Overview



<u>SIT used</u>: a single ADS string:

- 4 AIMs
- trunk cable
- anchor / buoy

Acoustic data received from the string was transmitted, via buoy radio to ADS radio, for ARS processing aboard the **USNS SIOUX**.

System Integration Test (SIT)

- **Objective:**
  - "Install an ADS Array (straight) with AIM/DTV"
  - The variance on "straight" impacts localization accuracy
- **6-13 November 2007**
- **Southern California**
- **Sea States 1 - 5**

Major System Test Effort
- 62 Test Personnel at Sea

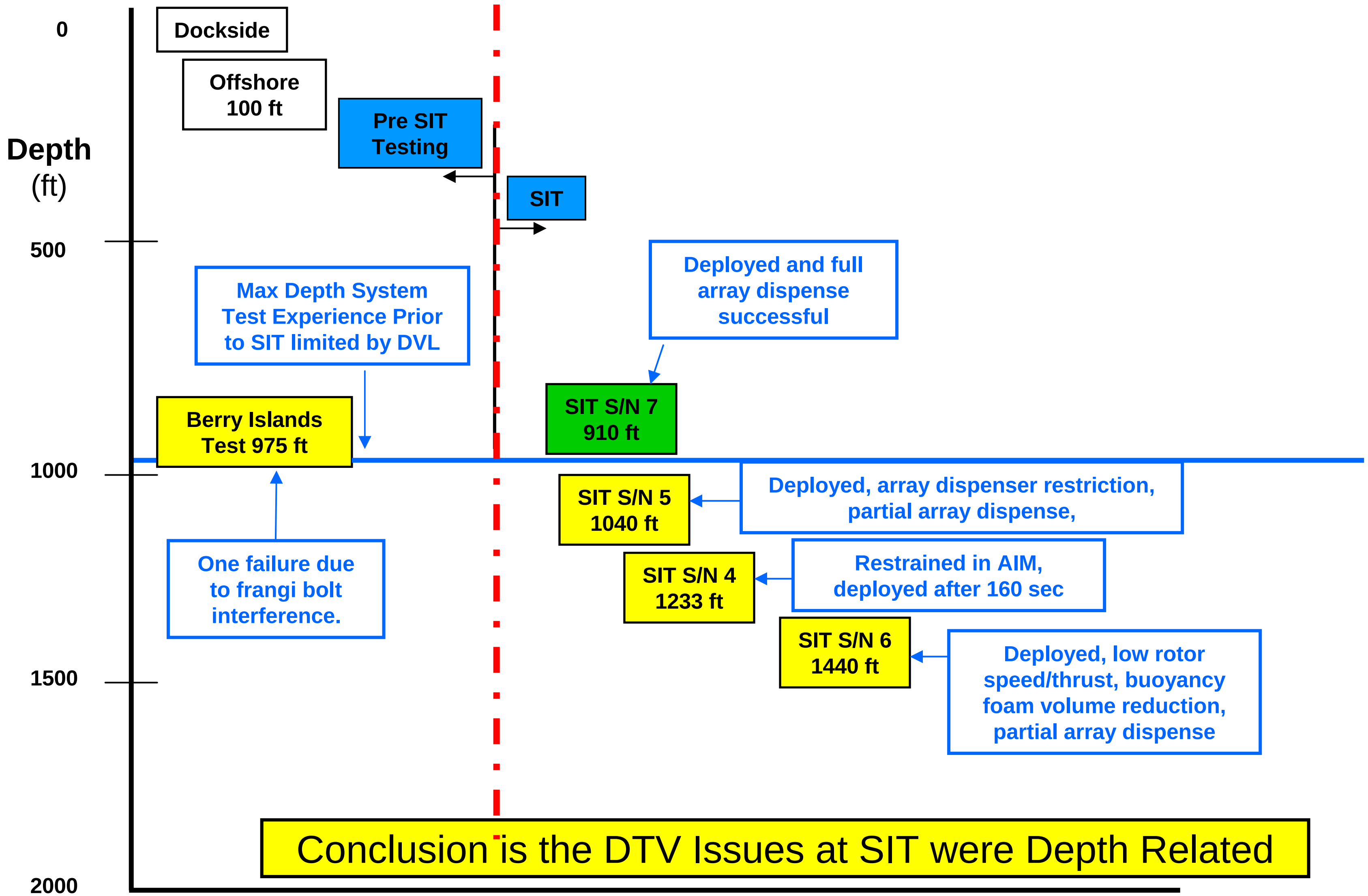
SIT Results

- **DTV anomalies – only 1 of 4 deployed the array properly**
- **Key Events**
  - Initial indications suggested all 4 arrays were successfully installed
  - After the ICP was initialized, determined the arrays did not deploy correctly on AIMs 1 through 3
    - AIM 4 electronics bottle later failed
  - Remote Operated Vehicle (ROV) used extensively
    - Bypassed AIM 4 by splicing cable from Node #3 to the buoy
    - Video confirmed the DTVs 1-3 failed to deploy arrays; each left the AIM, but only deployed a portion of the leader cable
    - Attached line to DTV so ship could pull array out (#1 and #2)
  - Manual deployment too late for SSN tracking (schedule issue); EMATT was used instead

Still Met 83% of Test Objectives at SIT

UNCLASSIFIED

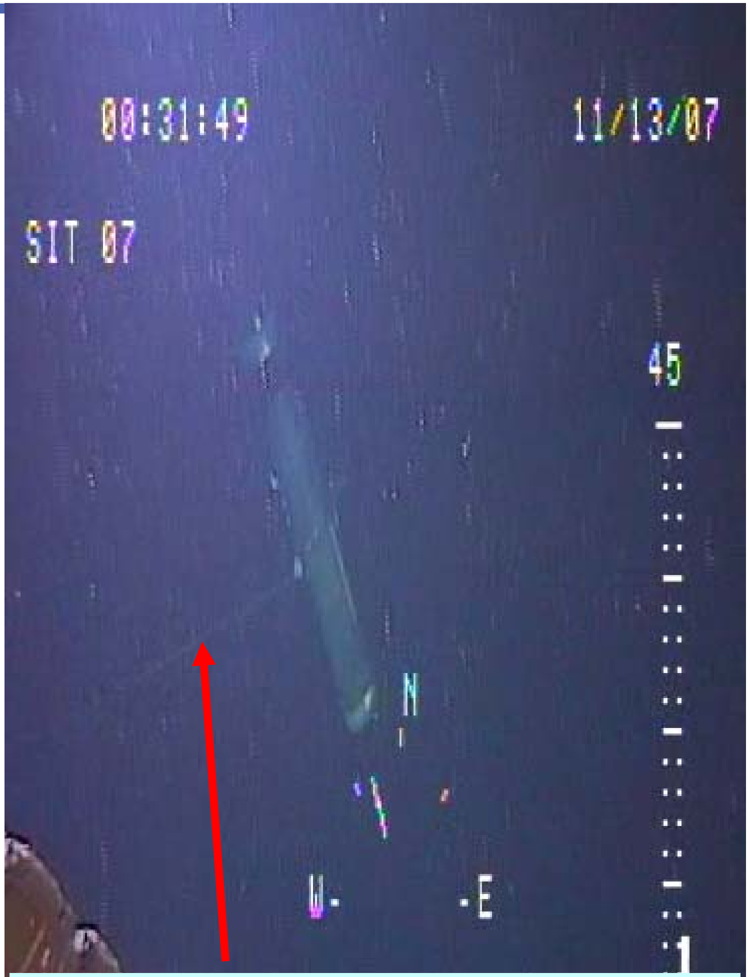
DTV Post-SIT Study



UNCLASSIFIED

ROV Video of DTV Operations

DTV on bottom after deployment with leader cable extending behind



DTV being pulled by ship to deploy the array

Lessons Learned from DTV Testing

1. **Vehicle control issues**
   - Must have sufficient Flow over Control Surfaces
   - Modeling did not accurately predict actual flow behavior
2. **Snood foam Compressed at max depth**
   - Design margin for Worst Case
3. **Release method needs to be as simple as possible**
   - Frangible bolts used; design issues / complications caused test failures
   - Issues masked other problems but schedule constraints precluded rerunning the test
4. **Insist on a Full Deployment Test at max depth**
   - Risk is significantly higher by not testing at max depth
5. **Verify pressure ratings of components that are subject to sea pressure**
   - Make this a Critical Design Review focus item
6. **Variable ballast should not have been Timer Controlled**
   - Only works if everything else is working; otherwise causes system failure

Recommendations

- **To re-use the DTV, we would:**

1. Upgrade the foam
    - Ensure all components can withstand sea pressure
2. Strengthen the transom plate
    - Verify components won’t bind under pressure
3. Design out the Variable Ballast Control Timer
    - Alter the DTV so the ballast varies as array cable is paid out
4. Reduce shock load on the AIM / Cable Pack
    - Consider the environment
5. Design out the frangible bolts
    - Keep it simple!

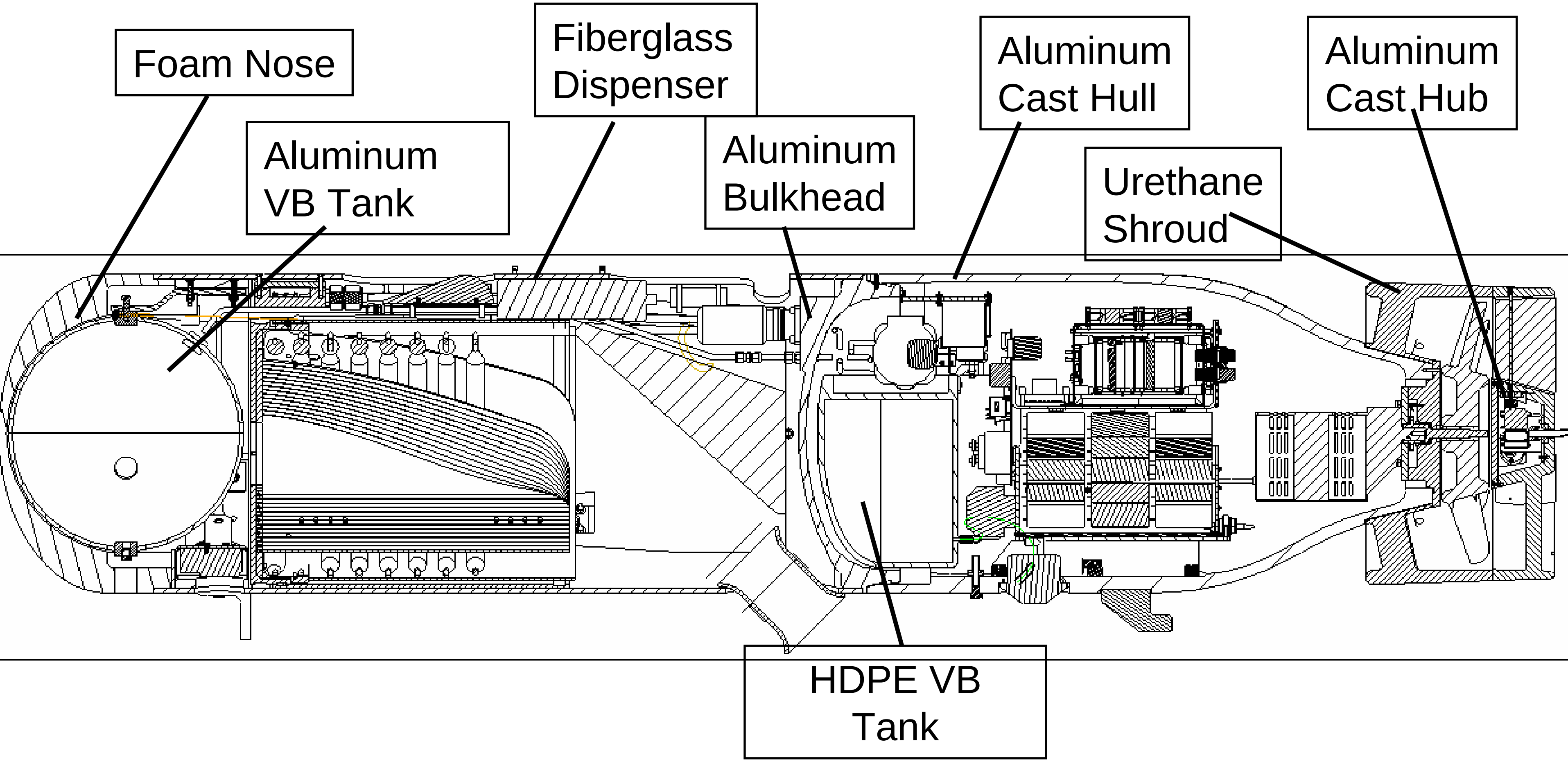
Summary

- **The Dispenser Transport Vehicle is a valid concept**

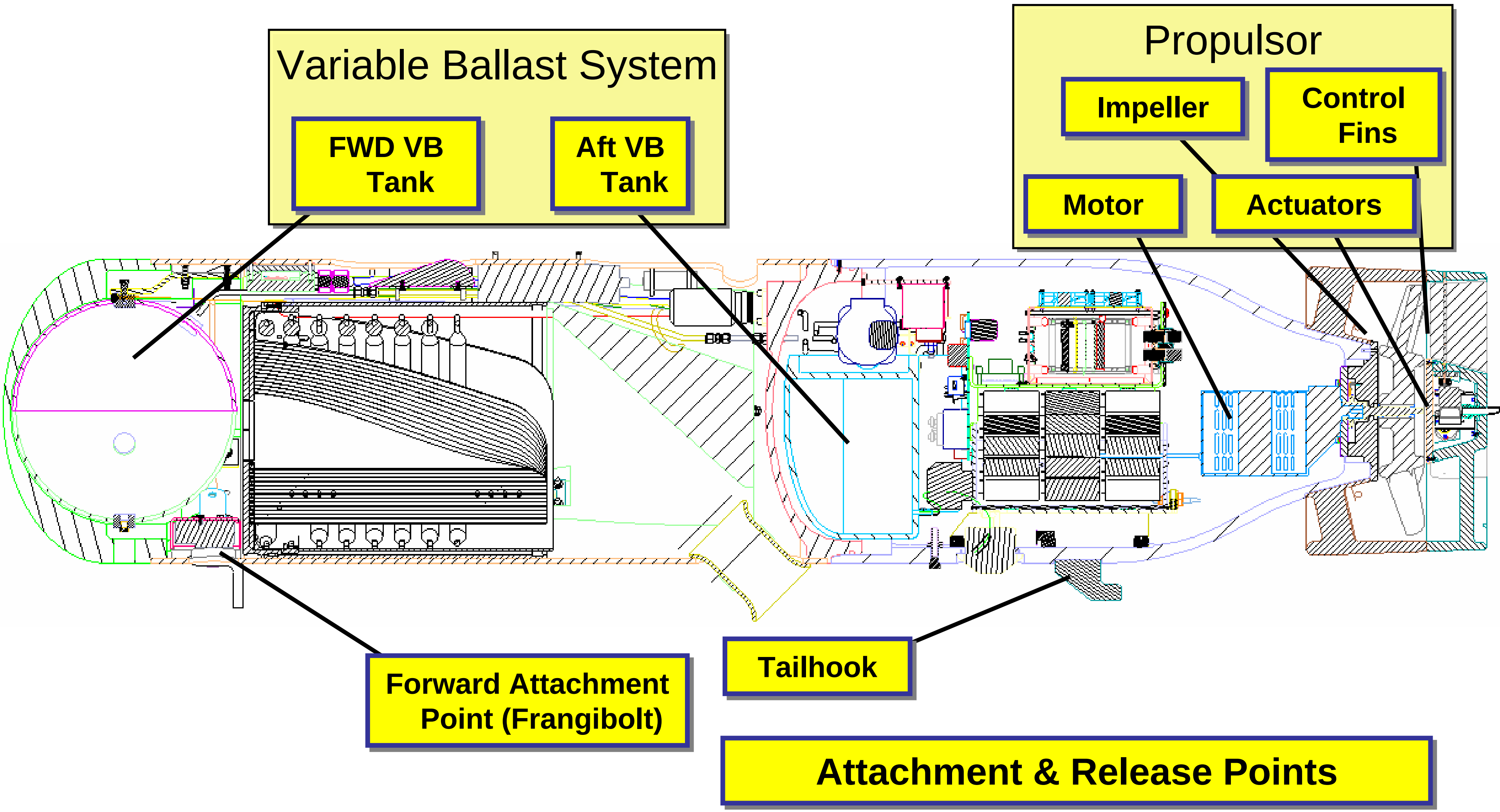
- **Remote installation is still highly desired at some sites and the DTV can be an enabler**
  - Some Design modifications and more testing is required

Backup

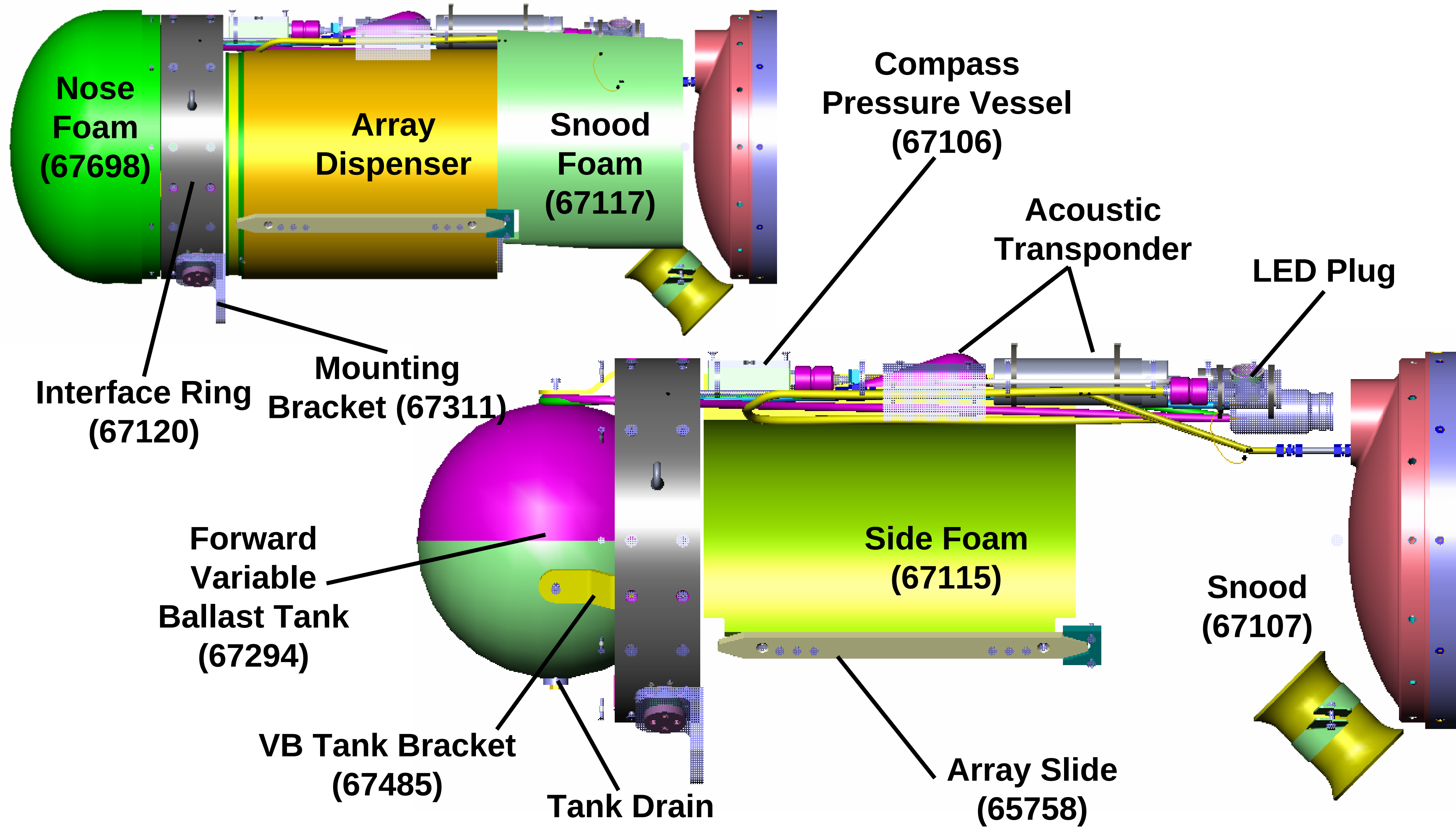
DTV Material



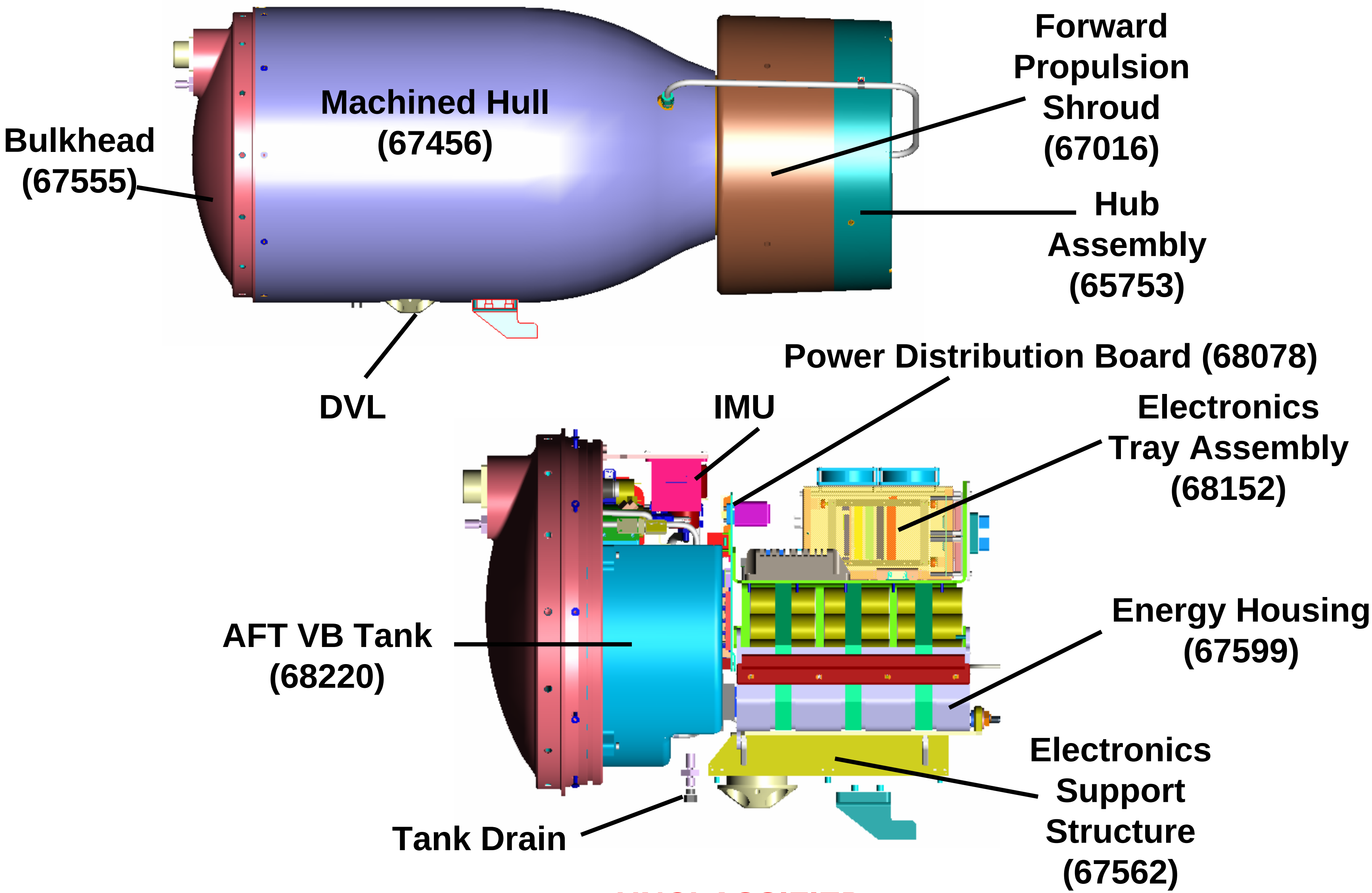
Vehicle Overview



Forward Section



Pressure Vessel



Organizations Involved in SIT

- Program Executive Office Littoral and Mine Warfare (PEO LMW)
- Maritime Surveillance Systems (PMS-485)
- Space and Naval Warfare Systems Center – San Diego (SSC-SD)
- Commander Undersea Surveillance (CUS)
- Commander, Operational Test & Evaluation Force
- Naval Facilities Engineering Service Center (NFESC)
- Johns Hopkins University – Applied Physics Lab (JHU-APL)
- Applied Research Lab – University of Texas (ARL-UT)
- Northrop Grumman
- Lockheed Martin

Organizations Involved in SIT

- Harris Corp
- Raytheon
- EADS
- AMRON
- SYS Technologies
- Science Applications International Corporation (SAIC)
- USNS SIOUX (T-ATF 171), USNS NAVAJO (T-ATF 169)
- USCGC ASPEN
- Sealift Logistics Command Pacific
- Fleet Imaging Center, Pacific, Combat Camera Group
- Fleet Area Control and Surveillance Facility
- National Centers for Environmental Prediction

Lessons Learned from SIT

- **Developmental Testing should rigorously verify each subsystem**
  - The DTV was tested deeper at SIT than in subsystem tests
- **Vigorously defend the T&E Program**
  - Articulate the potential impact of budget and schedule cuts
- **Augment the small government team with Subject Matter Experts**
  - Seek out those pre-eminent in their field

NDIA Requested Contact Data

- Speaker: Pete Reinagel
- Company: SYS Technologies
- Email: peter.reinagel@navy.mil or preinagel@systechnologies.com
- Phone: 619-524-7974 or 858-232-9230 cell


AFOTEC
AIR FORCE OPERATIONAL TEST AND EVALUATION CENTER

Test and Evaluation of Autonomous Systems

Air Force UAV Operational Test

Maj Gen Steve Sargeant

AFOTEC/CC

Presented to: 24th Annual National Test & Evaluation Conference, Palm Springs, CA
Presented on: Feb. 26, 2008

Purpose

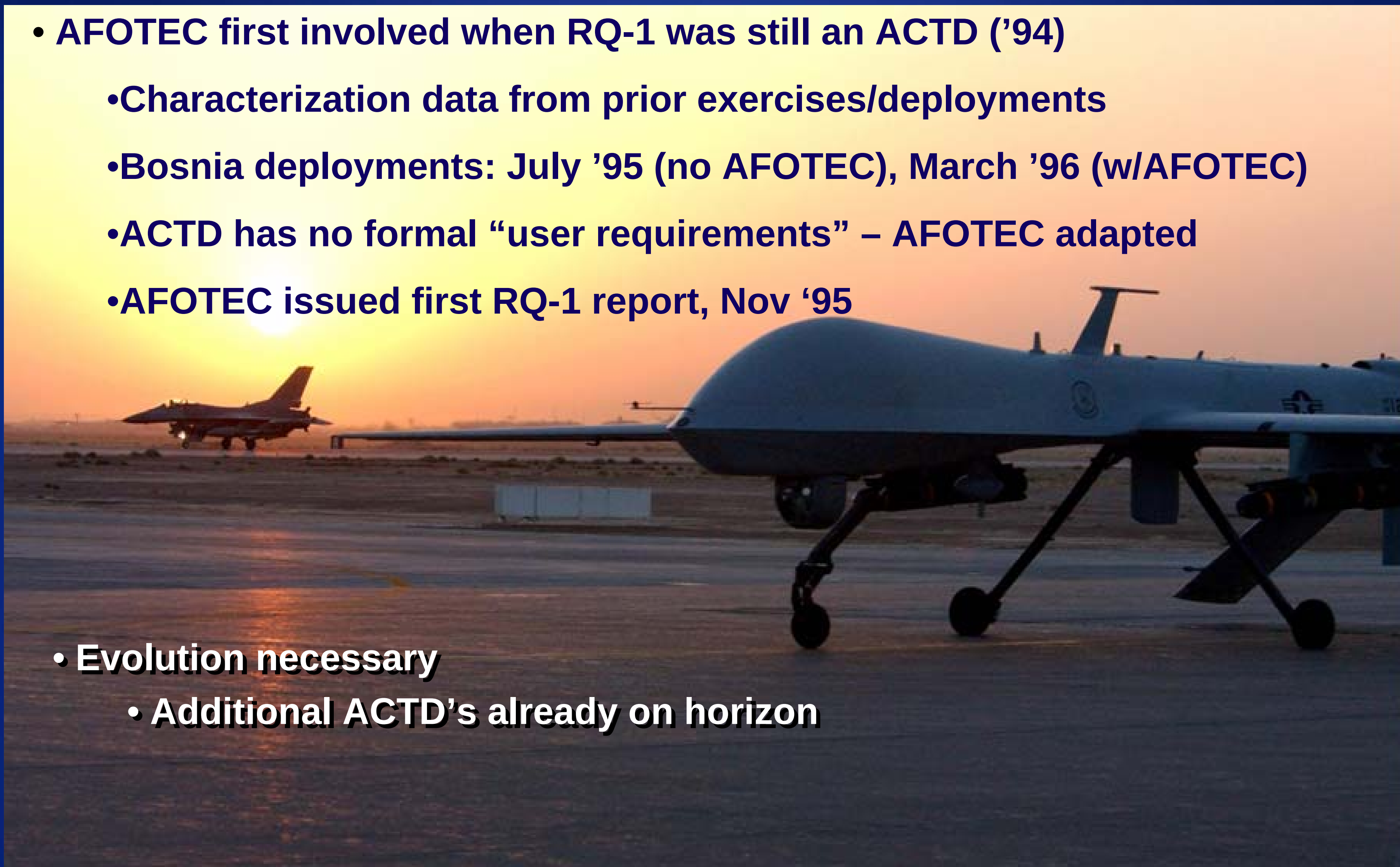
- Present AFOTEC's role in operational test of unmanned aerial vehicles

Overview

- AFOTEC Involvement
- Evolving Process
- Lessons Learned
- Future Challenges

AFOTEC Involvement

- AFOTEC first involved when RQ-1 was still an ACTD ('94)
  - Characterization data from prior exercises/deployments
  - Bosnia deployments: July '95 (no AFOTEC), March '96 (w/AFOTEC)
  - ACTD has no formal "user requirements" – AFOTEC adapted
  - AFOTEC issued first RQ-1 report, Nov '95



- Evolution necessary
  - Additional ACTD's already on horizon

Evolving Process

- Oct ’97, DARPA asks AFOTEC to evaluate Global Hawk
- AFOTEC prepared to add value

- Early Influence mindset evolved
- Rapidly met warfighter needs

Lessons Learned

- Agility and flexibility
  - Adapt tests if conducted in combat
- Test…then deploy
  - RQ-4 deployed during DT
  - Test vs mission mindset
- Surrogate platforms
  - Proteus for RQ-4
  - Saves time and money
- Early influence
  - Help refine requirements
  - Maximize DT/OT interface
- Rapid fielding
  - Capability to warfighter

Future Challenges

- National airspace restrictions
  - Training limit = Testing limit
  - Affects all UAVs
- Dedicated test assets
  - Communicate need early
  - CV-22 success
- Net-centric solutions
  - Architecture important as vehicle
  - Information assurance
  - Interoperability
  - Improve security

Summary Slide

- **Constant communication and coordination are important for AFOTEC to stay a step ahead**
  - **Refine requirements**
  - **Coordinate DT and OT**
- **There will be more ACTD’s in the future**

Rapid fielding of effective systems to allow warfighter to kill faster with less risk to our Airmen, Joint partners, and Allies

STM

24th ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

Test and Evaluation of Autonomous Systems & The Role of the T&E Community in the Requirements Process

STM AŞ

APPLICATION OF EVOLUTIONARY STRATEGIES FOR ACQUISITION OF AUTONOMOUS SYSTEMS

Dr. Ebru SARIGÖL   Nuri M.ÇERÇİOĞLU   Dr. Anıl KAREL

24th ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

Test and Evaluation of Autonomous Systems & The Role of the T&E Community in the Requirements Process

Presented By
Dr. Ebru SARIGÖL

Palm Springs, CA
26 February 2008

STM AŞ

APPLICATION OF EVOLUTIONARY STRATEGIES FOR ACQUISITION OF AUTONOMOUS SYSTEMS

Outline

- Introduction
- New Acquisition Environment: Evolutionary Acquisition
  - Development and Lifecycle models
- Testing in Evolutionary Acquisition Environment
- An Approach to Procurement of an Autonomous System
- Test Design with Staged Development
- Conclusion

- It is very often that a systems engineer faces to participate in procurement studies or make procurement decisions which affect significantly the success of a project.
- Procurement decisions may
  - be complex
  - involve inputs from many organizations
  - include technical and non-technical constraints.

Introduction

- MAIN AIM: to fulfil/achieve/realize the procurement of users /the demanding authority in a reasonable time interval.
- Many parameters
  - budget
  - procurement time
  - user and/or system needs
  - properties of the system to be procured
  - priorities of the sub-systems present in the system (indispensable, should be, preferable)
  - technological maturity/perfection
  - technologies to be developed
  - possibility of retreofil of the of the system
  - determination of the tests to be done
  - timing of the tests.

- Evolutionary acquisition (EA) is a process for defense system development in which a system is developed in stages as a part of a single acquisition program.
- The different stages can be additional hardware and software capabilities or performance gains due to advances in technological maturity and reliability growth.

New Acquisition Environment

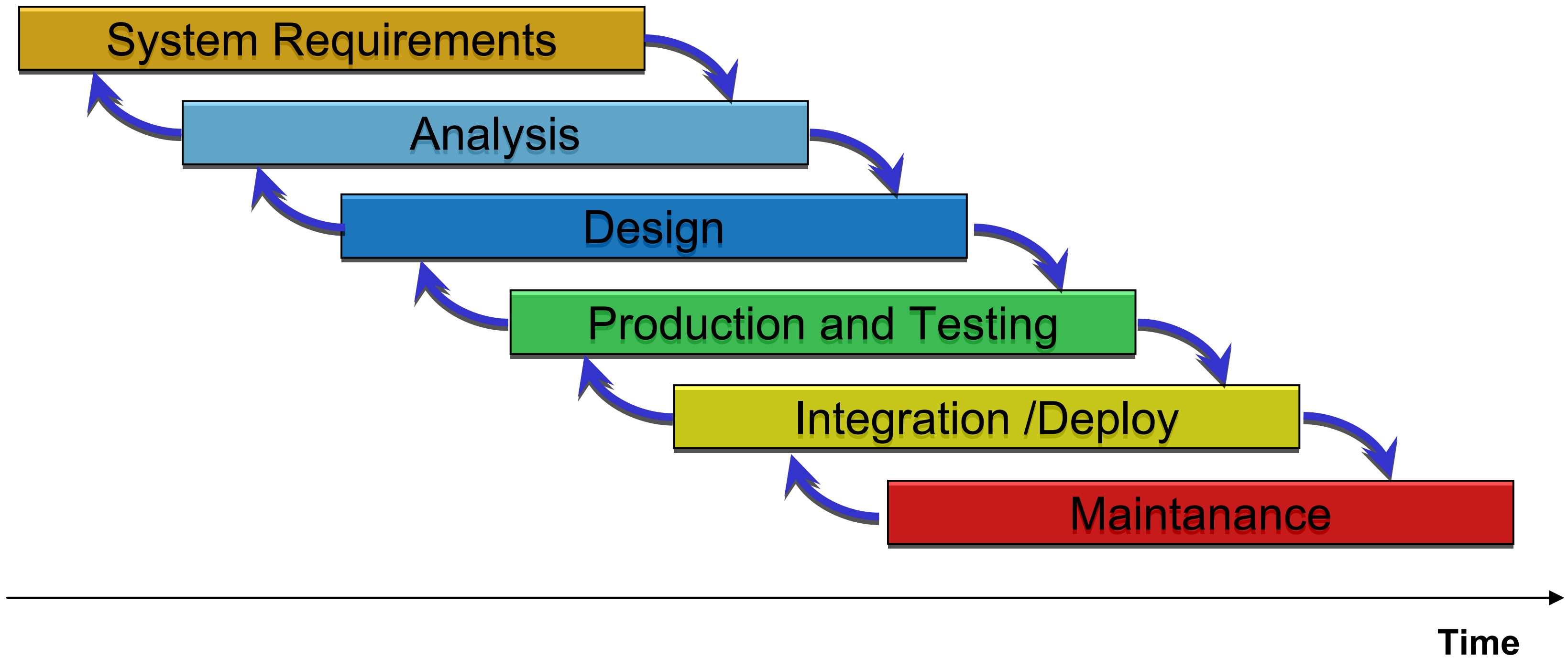
- In an evolutionary approach, the ultimate capability delivered to the user is provided in increasing increments.
- Evolutionary acquisition strategies
  - (1) define, develop, produce and deploy an initial, military useful capability (Increment 1) based on proven technology, demonstrated manufacturing capabilities and time-phased capabilities needs;
  - (2) plan for subsequent development, production and deployment of increments beyond the initial capability over time (Increments 2 and beyond).

New Acquisition Environment

- There are various development and Lifecycle models to support systems engineering within an evolutionary acquisition strategy.
  - waterfall
  - iterative
  - spiral development
  - Vee

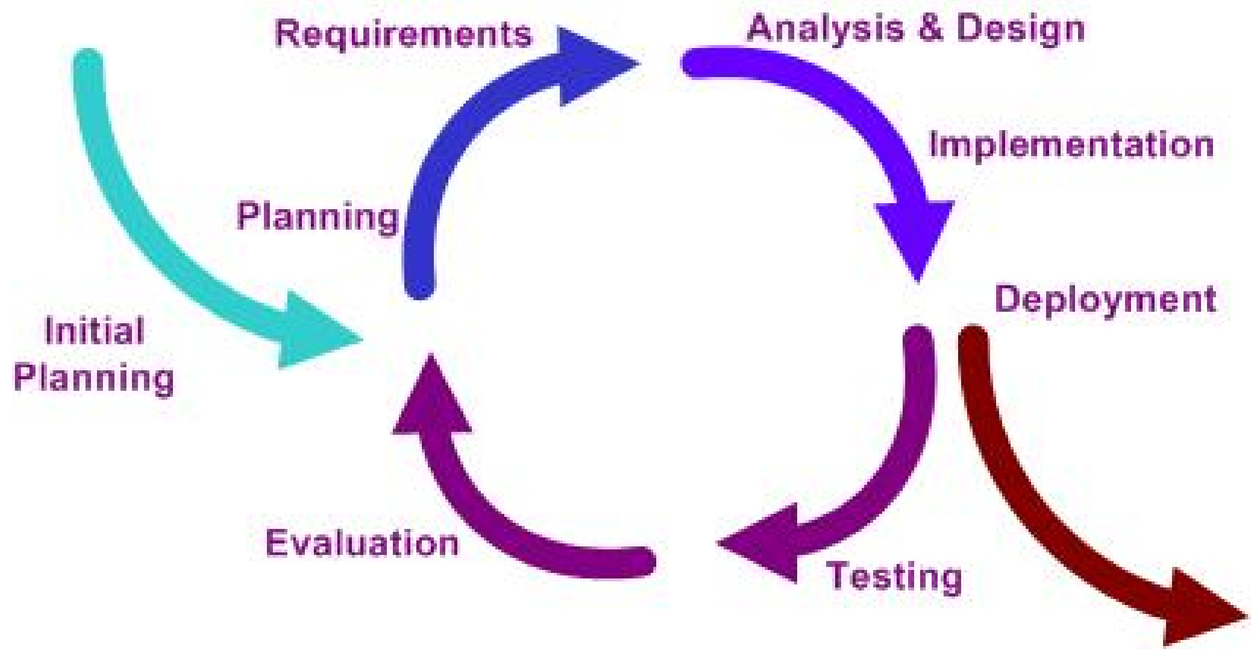
Waterfall Model

- It is a sequential software development model (a process for the creation of software) in which development is seen as flowing steadily downwards (like a waterfall) through the phases of project



Iterative Model

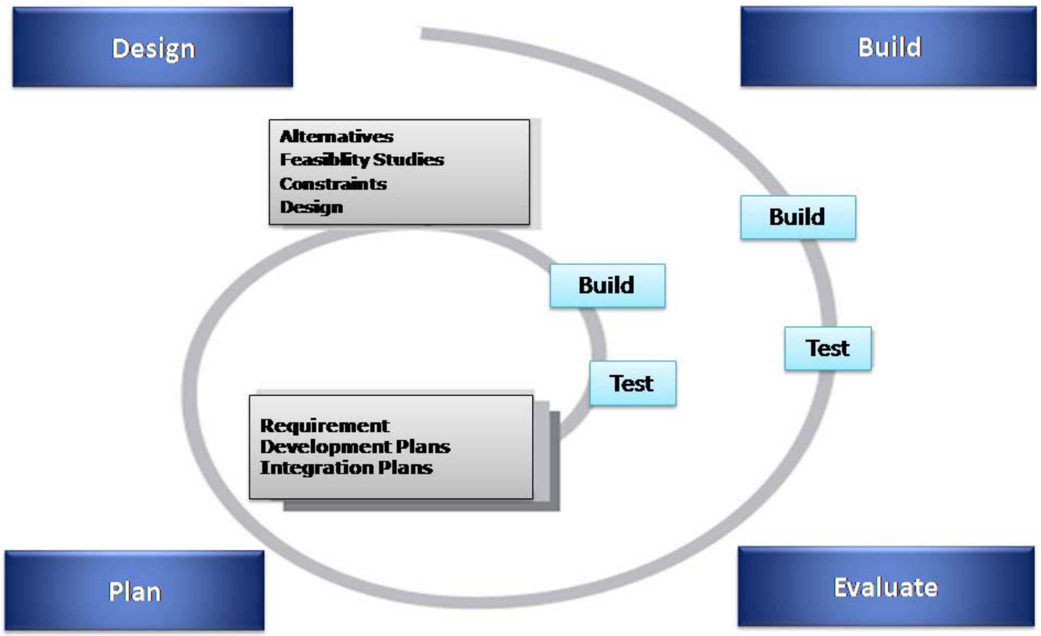
- Iterative development is a rework scheduling strategy in which time is set aside to revise and improve parts of the system.
- It does not presuppose incremental development, but works very well with it.



STM

Spiral Development Model

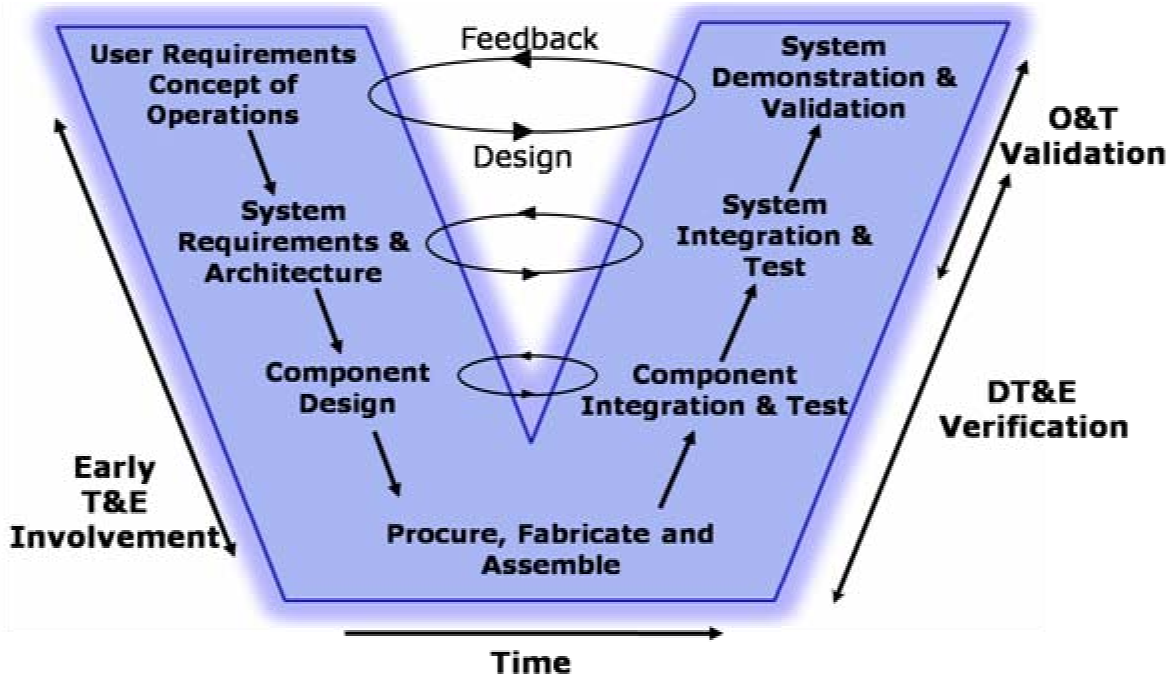
- a systems development method used in information technology.
- combines the features of the prototyping model and the waterfall model.
- favored for large, expensive, and complicated models



STM

Vee-Model

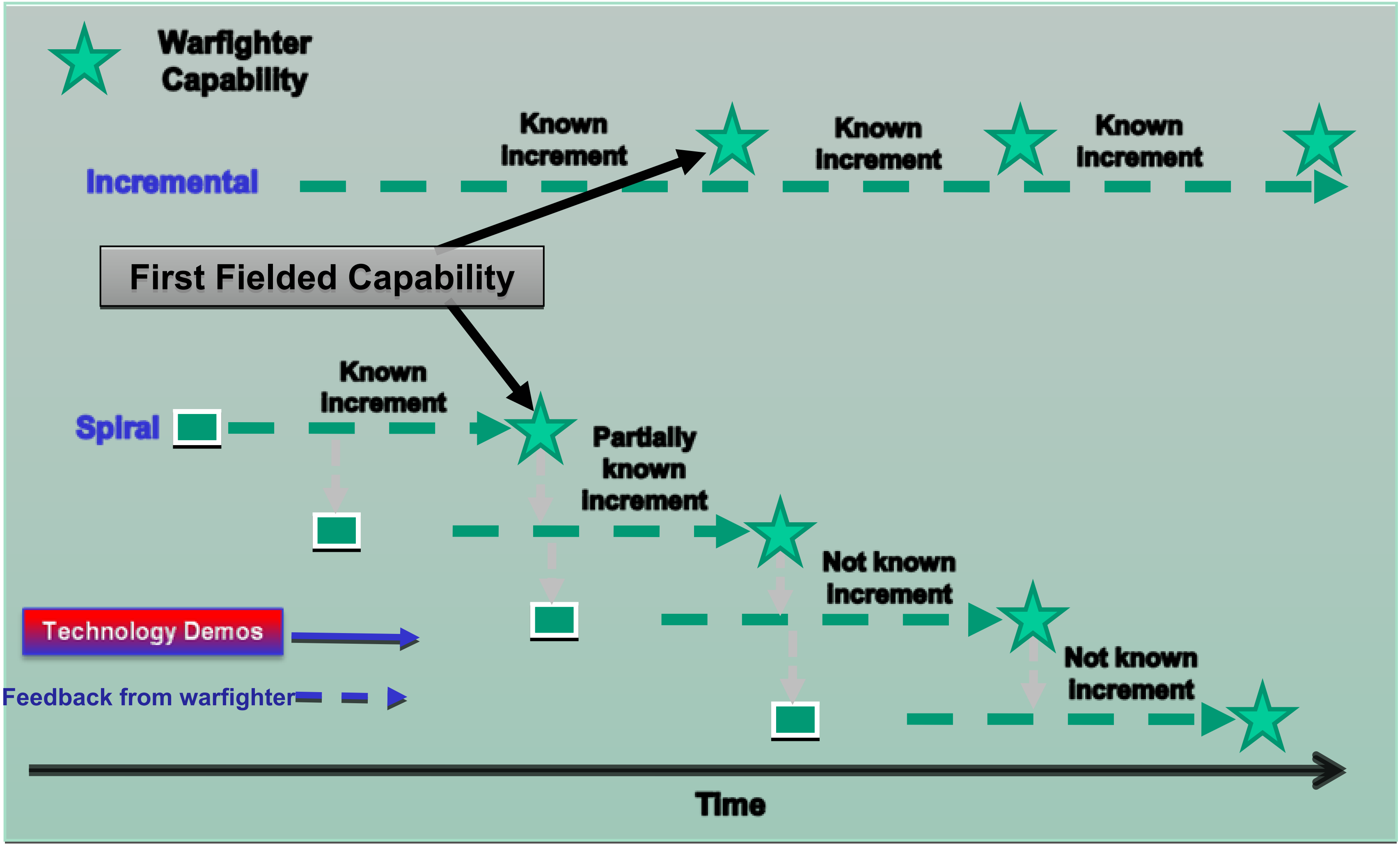
- a systems development model designed to simplify the understanding of the complexity associated with developing systems.
- used to define a uniform procedure for product of project development.



- All models provide an orderly approach to implementing and integrating the systems engineering processes during each acquisition phase.
- Waterfall model is not practical to imply for all systems
- In iterative model, the end-state requirement should be known but this model allows earlier delivery of initial planned system
- In spiral and incremental development, capability is developed and fielded in increments with each successive increment building upon earlier increments to achieve an overall capability.
- The spiral and Vee models rely heavily on prototyping, both physical and virtual, to get user feedback.

STM

Comparison of the incremental and spiral evolutionary processes



Evolutionary Acquistion is a strategy not a model

- Can be adjusted for any project
- General description of desired full system functional capability
- Concise statement of full system operational concepts
- Flexible overall architecture allowing incremental design
  - One method is the use of Open Systems Architecture
- Plan to incrementally achieve desired total capability
- Early definition, funding, development, testing, supporting and operational evaluation of initial increment of operational capability
- Continual dialogue and feedback among users, developers, supporters and testers

- **Evolutionary** acquisition
  - increased the importance of traceability in program management.
    - If a defense system has multiple increments, systems engineering can trace the evolution of the system.
    - It can provide discipline to and documentation of the repeated trade-off analyses and decisions associated with the program.
  - Due to the nature of **evolutionary** acquisition, design, development, deployment, and sustainment can each be occurring simultaneously for different system increments.

Testing in Evolutionary Acquisition Environment

STM

- Test and evaluation may be at the end of the development phase which was the path in earlier and simple procurement models
- leads to a deficiency in the technological maturity level as well as an increase in acquisition time of the required system.
- Instead integrated test and evaluation should be preferred for the optimization of procurement time and necessary technological maturity level

Testing in Evolutionary Acquisition Environment

- In the evolutionary acquisition context
  - experimentation in early stages
    - to identify system flaws
    - understand the limitations of system design.
  - experimentation in later stages
    - problems identified in the field and/or unresolved from earlier testing
    - evaluating the most recent modifications to the system, and assessing the maturity of a new component or subsystem design.
      - ☑ This experimentation can be at the component level, at the subsystem level, or at the system level, with varying degrees of operational realism, depending on the goals.

Testing in Evolutionary Acquisition Environment

- Operational testing and evaluation supports a decision to pass or to fail a defense system before it goes to procurement.
- In EA, entire spectrum of testing activities should be viewed as a continuous process of gathering, analyzing, and combining information in order to make effective decisions.
- The primary goal of test programs should be to experiment, learn about the strengths and weaknesses of newly added capabilities or (sub)systems, and use the results to improve overall system performance.
- Furthermore, data from previous stages of development, including field data, should be used in design, development, and testing at future stages.

Testing in Evolutionary Acquisition Environment

- Operational testing (testing for verification) of systems still has an important role to play in the evolutionary environment, although it may not be realistic to carry out operational testing comprehensively at each stage of the development process.
- Testing early in the development stage should emphasize the detection of design inadequacies and failure modes.
- In evolutionary acquisition, it will be practical to conduct full-scale operational tests only at stages with major upgrades or substantive new capabilities.
- In the evolutionary acquisition environment, effective system development and optimization will require a high degree of coordination and communication among system developers, government testers, and system users.

Testing in Evolutionary Acquisition Environment

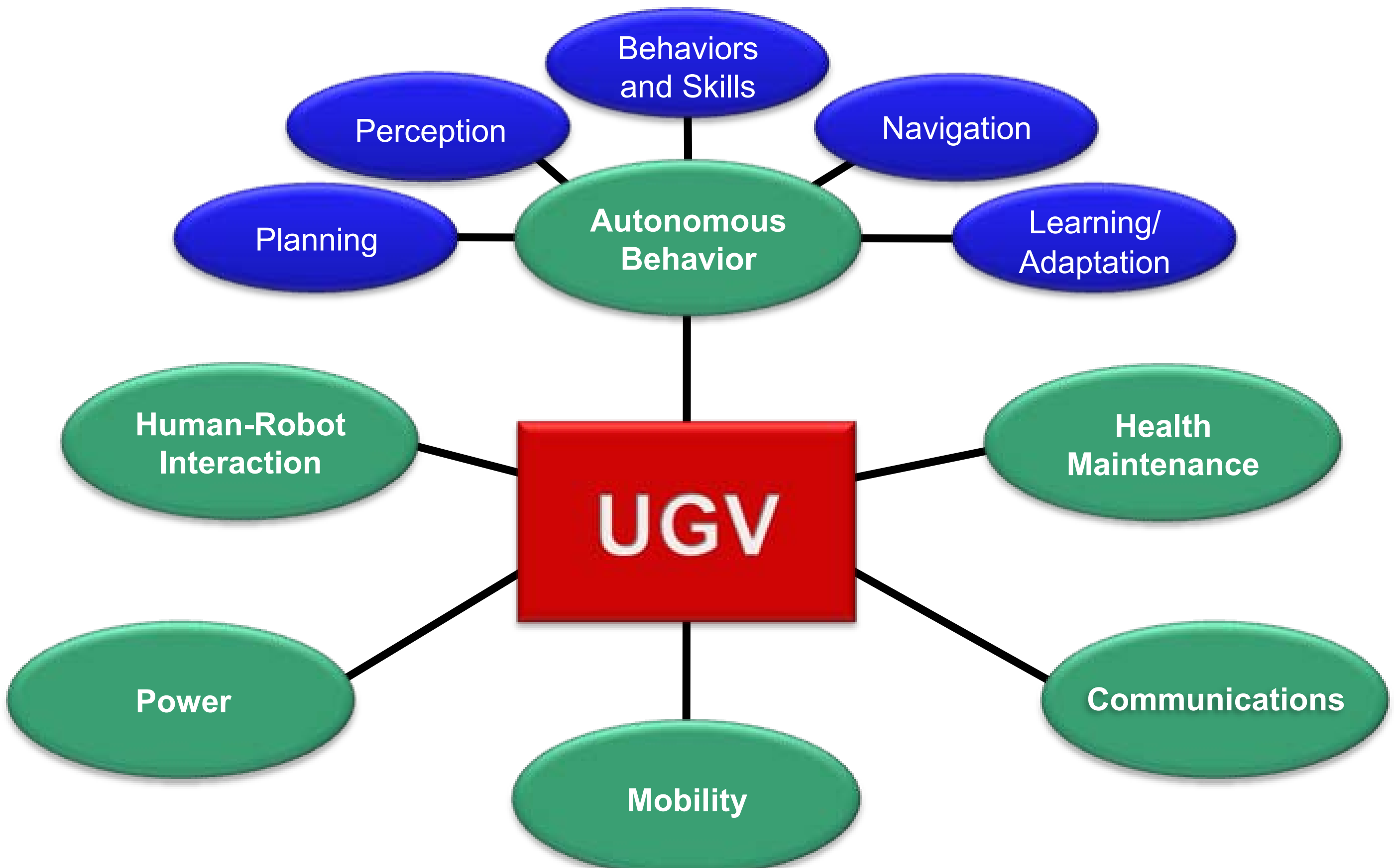
- The traditional single-stage acquisition environment can encourage the adoption of risky, immature technology into an existing system, since it may take a decade or more before a new technology can be incorporated.
- Regardless of the introduction of evolutionary acquisition, the increasing complexity of defense systems implies that a single all-encompassing, large-scale operational test, as currently practiced, will not be feasible in many cases.

Testing in Evolutionary Acquisition Environment

- Evolutionary acquisition is being folded into an acquisition environment that already has a counterproductive incentive system. The flexibilities inherent in the evolutionary acquisition process present even greater opportunities for these counterproductive incentives to be expressed.
- Testing early in the development stage should emphasize the detection of design inadequacies and failure modes. This will require testing in more extreme conditions than those typically required by either developmental or operational testing, such as highly accelerated stress environments.

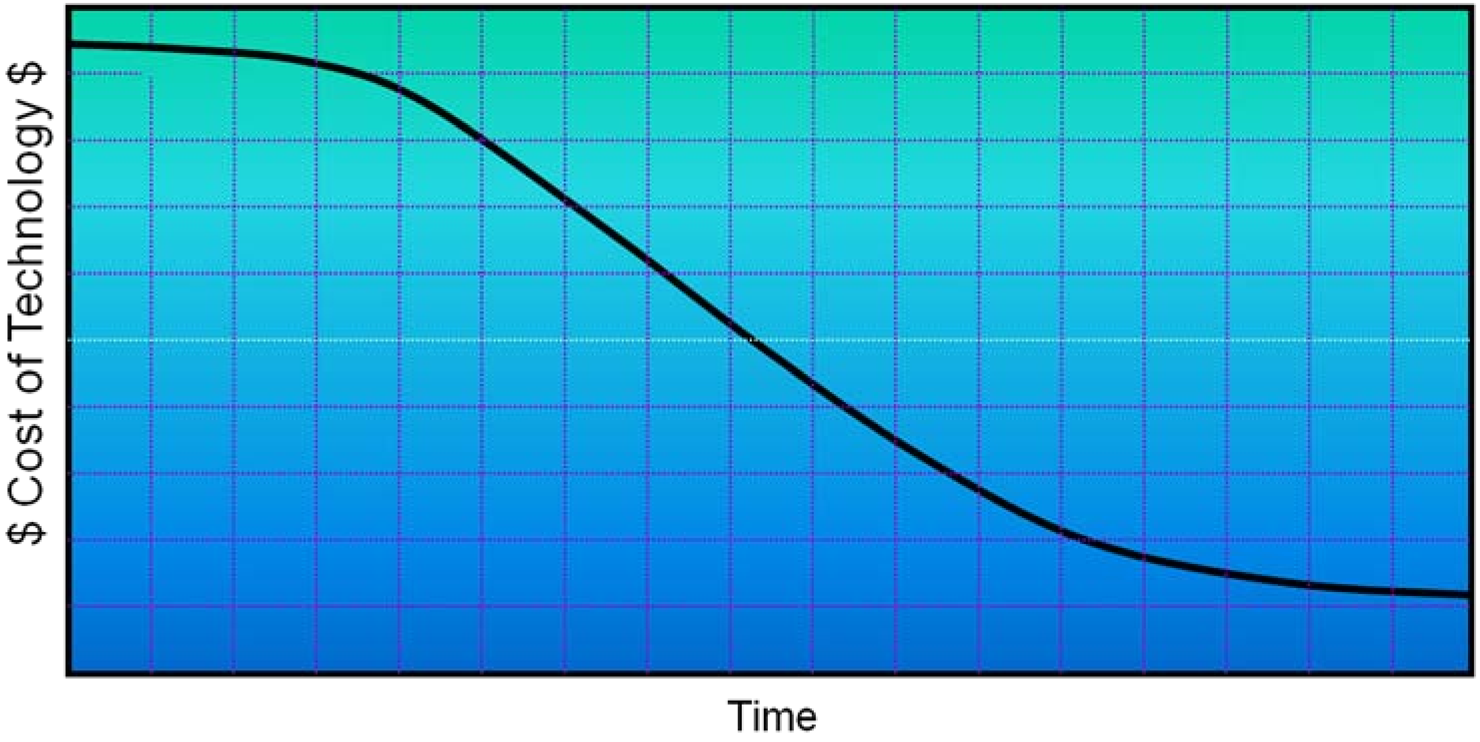
An Approach to Procurement of Autonomous System

- Autonomous Behavior Technologies
- Supporting Technologies

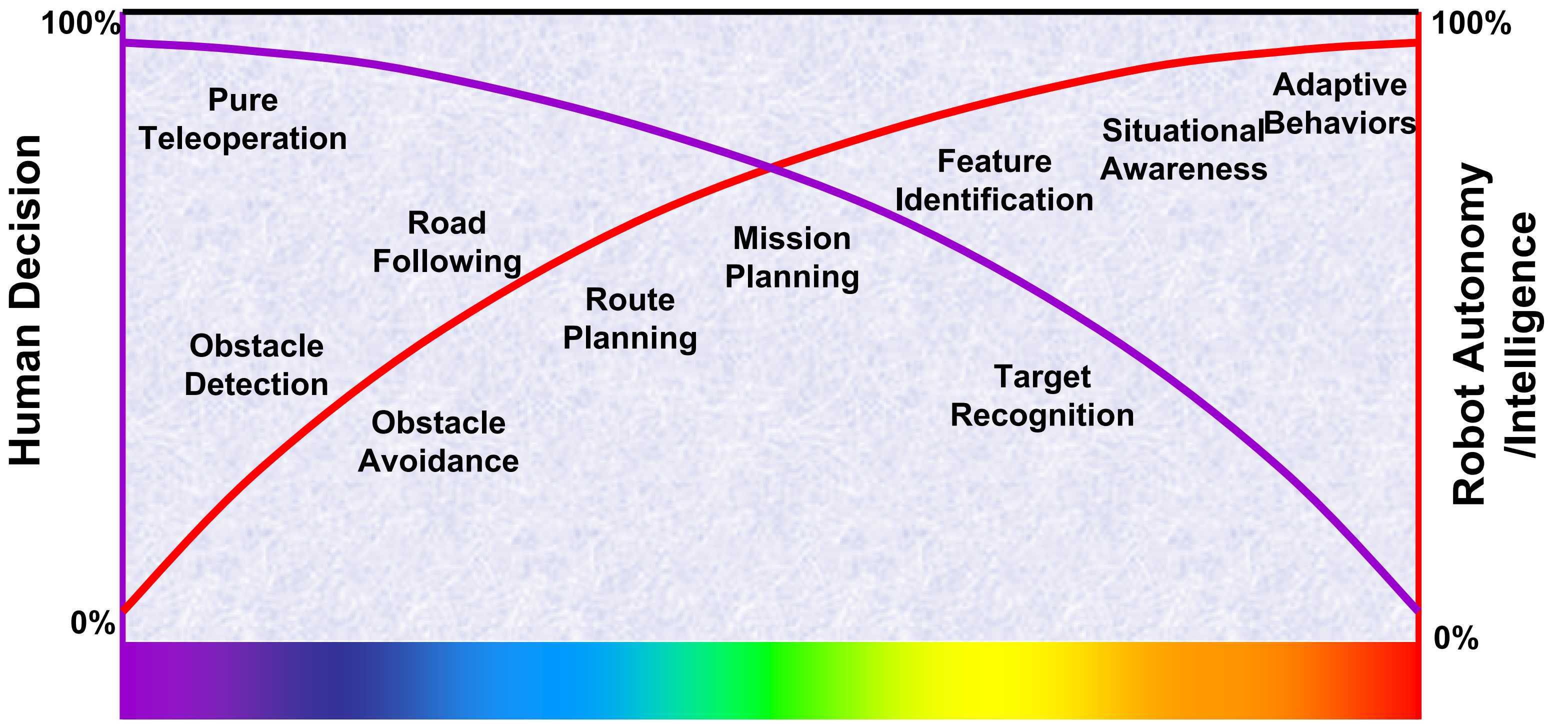


An Approach to Procurement of an Autonomous System

- Field systems with today's reliable & affordable technology
- Insert new technologies as they become reliable & affordable



An Approach to Procurement of an Autonomous System



An Approach to Procurement of an Autonomous System

- The development process will be best served by systematic and extensive testing and refinement under severe operating conditions.
- Focusing on a few specific applications for the experimental prototypes, some of which may be simulated, is essential to maturing the needed technologies and resolving the significant issues of system integration.

- The user and developer communities must work together to provide direction for the technology integration to implement vehicle experiments.
- These directions should feed into the spiral development process from experimental prototypes to requirements-based systems following the established development process.
  - i.e. application parameters must be formulated to address the integration of the mission-package technologies, mobility technologies, and communications technologies that are necessary for each experimental prototype.

A SIMPLE EXAMPLE WITH TWO FACTORS

$$Y = \beta_{00} + \beta_{10} x_1 + \beta_{20} x_2 + \varepsilon$$

Stage (k-1) ⇨ **SUNNY** vs **RAINY**

For details see “Testing of Defense Systems in an Evolutionary Acquisition Environment”

Stage (k) ⇨ **NIGHT VISION CAPABILITY**

$$Y = \beta_{00} + \beta_{10}\, x_1 + \beta_{20}\, x_2 + \beta_{12} x_1 x_2 + \varepsilon$$

Test scenarios with more than two levels and quadratic terms:

$$Y = \beta_{00} + \beta_{10}\, x_1 + \beta_{11} x_1^2 + \beta_{20}\, x_2 + \beta_{21} x_2^2 + \beta_{12} x_1 x_2 + \varepsilon$$

EXTENSIONS TO MORE REALISTIC SCENARIOS

- *New test scenarios*
- $Y = f^{(k)}(x;\beta)$

$$f^{(k)}(x;\beta) = \lambda_1 f^{(k-1)}(x_1;\beta_1) + \lambda_1 \underbrace{g^{(k)}(x_2;\beta_2)}_{\text{Effects of new factors in current stage}}$$

Test Design with Staged Development

- Do full operational testing and integration testing only after substantial stages.
- Do limited integration testing at intermediate stages at which modifications are small to moderate.
- Build in realism in developmental tests and carry out full component testing in developmental test.

Conclusion

- Test planning should be in the early stages of procurement
- Important features in test planning
  - procedures to be followed according to different test types (prototype development tests, sub-system tests, acceptance tests)
  - attandees to the tests
  - the criteria
  - evaluation
  - test reports
  - the conditions for the next step
- Test structure

Conclusion

- Evolutionary acquisition for procurement in defense systems
  - Evolutionary acquisition strategies
    - integrate advanced, mature technologies into producible systems that can be deployed to the user as quickly as possible.
    - match available technology and resources to approved, time-phased, capability needs.

Conclusion

- Testing is an important milestone for the procurement of unmanned vehicles
- A test center for unmanned vehicles
  - Repeatable test scenarios
  - Avoid loss of experience and knowledge

THANK YOU

Dr. Ebru SARIGÖL	**esarigol@stm.com.tr**
Nuri M. ÇERÇİOĞLU	**ncercioglu@stm.com.tr**
Dr. Anıl KAREL	**akarel@stm.com.tr**

KAFKAS SOKAK NO:56 BEŞTEPE, 06510 ANKARA
TEL : +90 (312) 223 68 00 FAX : +90 (312) 223 68 18

www.stm.com.tr

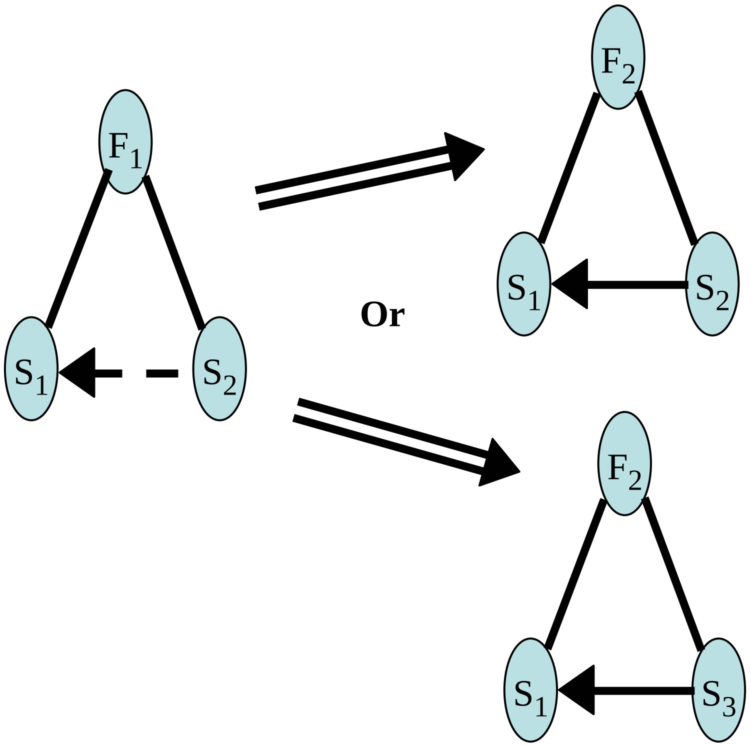
Substance Field Modeling: Measurement and Detection

AIR ACADEMY ASSOCIATES
Simplify, Perfect and Innovate

The Inventioneering Company

Michael S. Slocum, Ph.D., T.Sc., M.B.B.

Substance-Field Modeling (SFM)



Why A Model ?

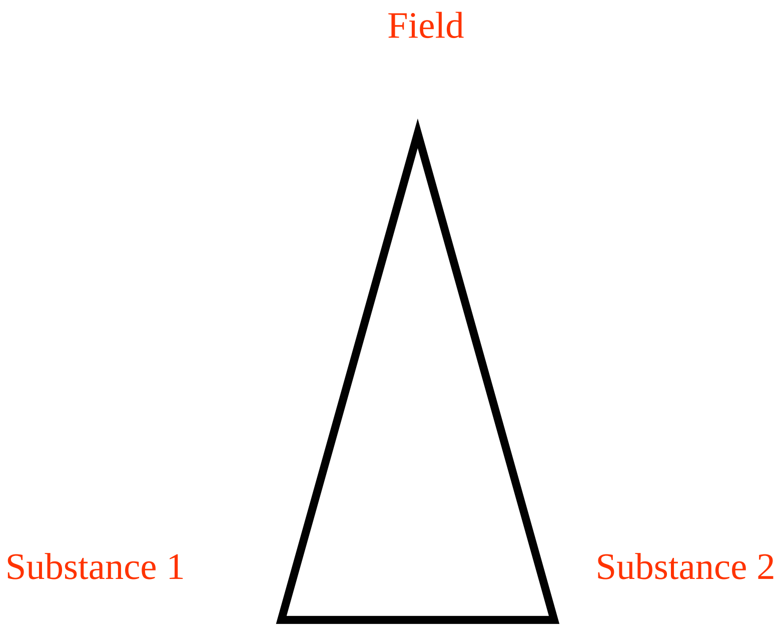
- Some systems need modeled in order to understand the inequalities and inconsistencies that manifest as problems or insufficiencies
- Complex systems may be better understood with the use of a model
- A SFM identifies specific problem types and then offers solution standards

SFM Defined

- Su-Field models are pictorial representations of the elements in the system and the field through which the elements interact.
- These are formed into triangular diagrams
- The diagrams are analyzed for defects
- The particular defect type yields solution standards

Minimum Model of a Functioning Technical System (SFM)

- Object 1, Substance 1
- Object 2, Substance 2
- Field or force (energy)
- Object 1 interacts with Object 2 through the field or force, Field
- Model system using triangle



A complete SFM with no defects

The Model

- Substance 1 is known as the *workpiece*
- Substance 2 is known as the *tool*
- The *tool* is applied to the *workpiece*
  - this is the flow of energy through the model
- The *field* is the connecting component

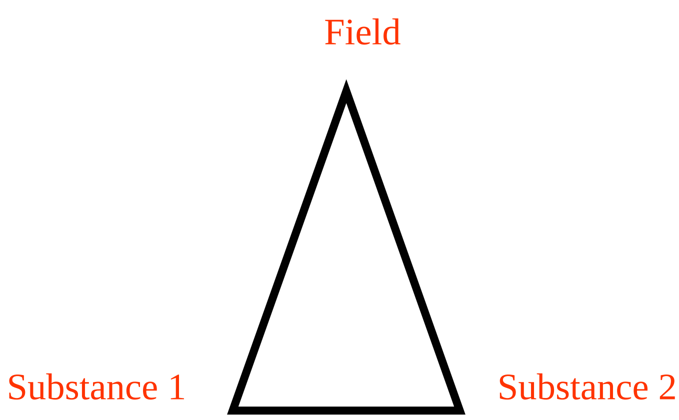
The *Field*

- The *Field* is divided into sub-groups:
  - Me: mechanical
  - Th: thermal
  - Ch: chemical
  - E: electrical
  - M: magnetic
  - EM: electromagnetic
- The subgroup is used as a subscript to the F in the Su-Field Model (i.e., F_{Me}, F_{Ch})

Example

A person is painting a wall:

- S1: wall (workpiece)
- S2: person (tool)
- F: painting (mechanical field)



Different Levels of Modeling

- S1: wall
- S2: person
- F: painting

- S1: wall
- S2: paint
- F: adhesion

- S1: wall
- S2: brush
- F: application

- S1: paint
- S2: brush
- F: application

- S1: brush
- S2: person
- F: moving application

76 Standard Solutions

- The 76 Standard Solutions were developed from patterns of solutions of technological / transactional problems

76 Standards of Solutions

- The Solutions are broken into 5 Classes
  - Class 1 – Composition and Decomposition of SFMs
  - Class 2 – Evolution of SFMs
  - Class 3 – Transition to Super-system and Micro-level
  - **Class 4 – Measurement and Detection Standards**
  - Class 5 – Helpers

The 5 Classes

CLASS 1. COMPOSITION AND DECOMPOSITION OF SFMS

GROUP 1-1: SYNTHESIS OF A SFM
GROUP 1-2: DECOMPOSITION OF SFMS

CLASS 2. EVOLUTION OF SFMS

GROUP 2-1: TRANSITION TO COMPLEX SFMS
GROUP 2-2: EVOLUTION OF SFM
GROUP 2-3: EVOLUTION BY COORINATING RHYTHMS
GROUP 2-4: FERROMAGNETIC SFMS (FESFMS)

CLASS 3. TRANSITIONS TO SUPERSYSTEM AND MICROLEVEL

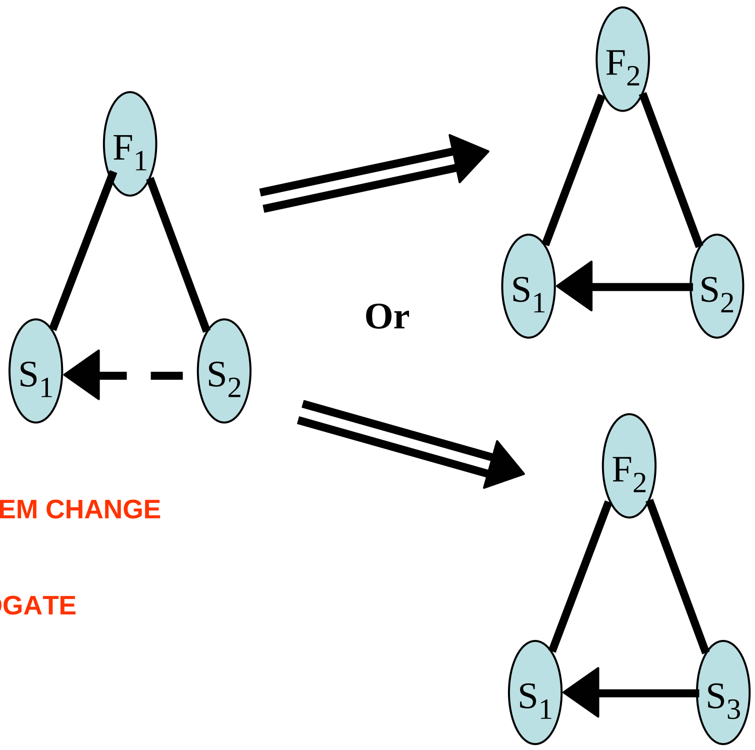
GROUP 3-1: TRANSITIONS TO BISYSTEM AND POLYSYSTEM
GROUP 3-2: TRANSITION TO MICROLEVEL

CLASS 4. MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: INSTEAD OF MEASUREMENT AND DETECTION - SYSTEM CHANGE
GROUP 4-2: SYNTHESIS OF A MEASUREMENT SYSTEM
GROUP 4-3: ENHANCEMENT OF MEASUREMENT SYSTEMS
GROUP 4-4: TRANSITION TO FERROMAGNETIC OR OTHER SURROGATE MEASUREMENT SYSTEMS
GROUP 4-5: EVOLUTION OF MEASUREMENT SYSTEMS

CLASS 5. SPECIAL RULES OF APPLICATION

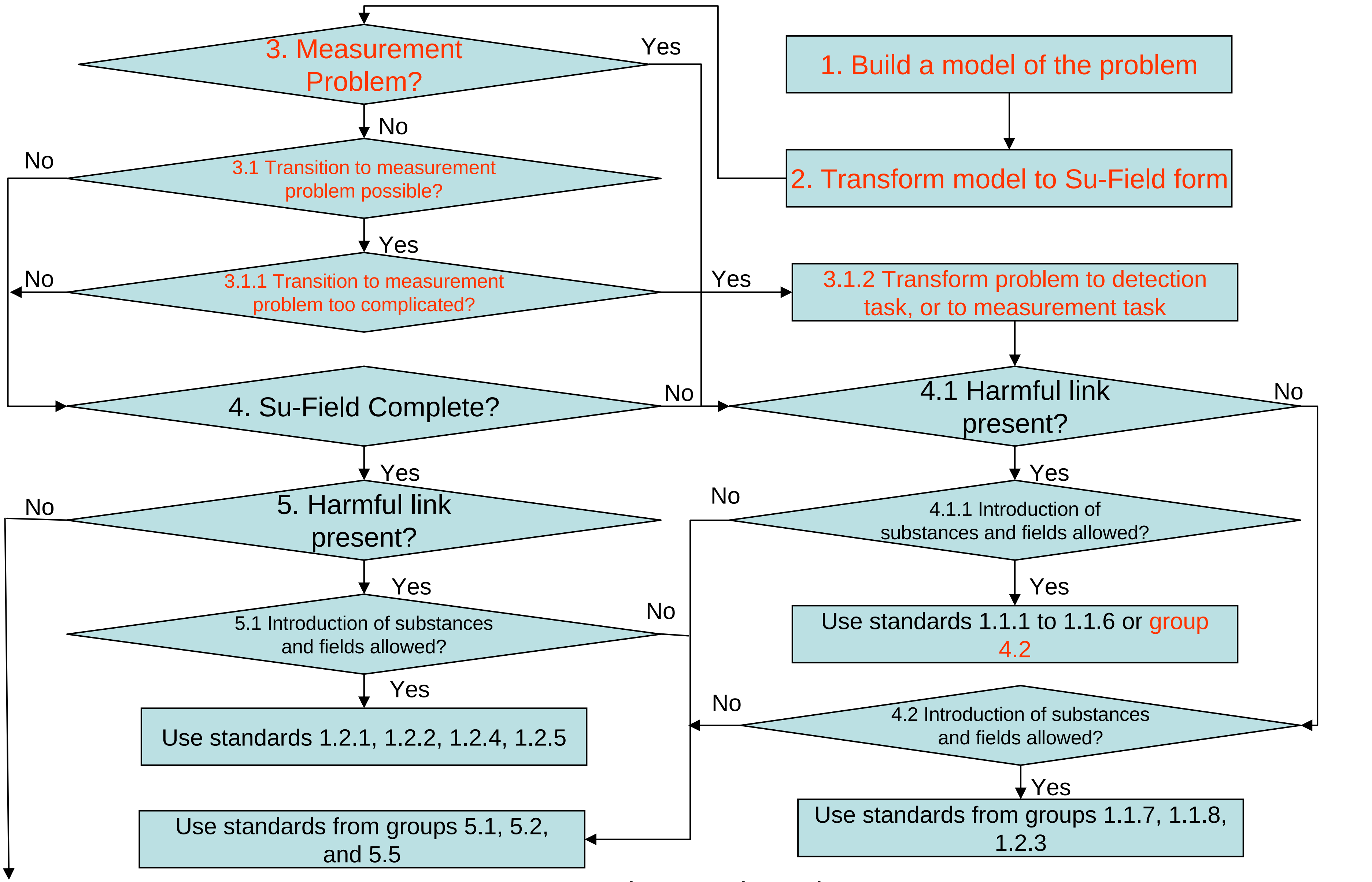
GROUP 5-1: SUBSTANCE INTRODUCTION
GROUP 5-2: INTRODUCTION OF FIELDS
GROUP 5-3: USE OF PHASE TRANSITIONS
GROUP 5-4: PHYSICAL EFFECTS USE
GROUP 5-5: SUBSTANCE PARTICLES OBTAINING

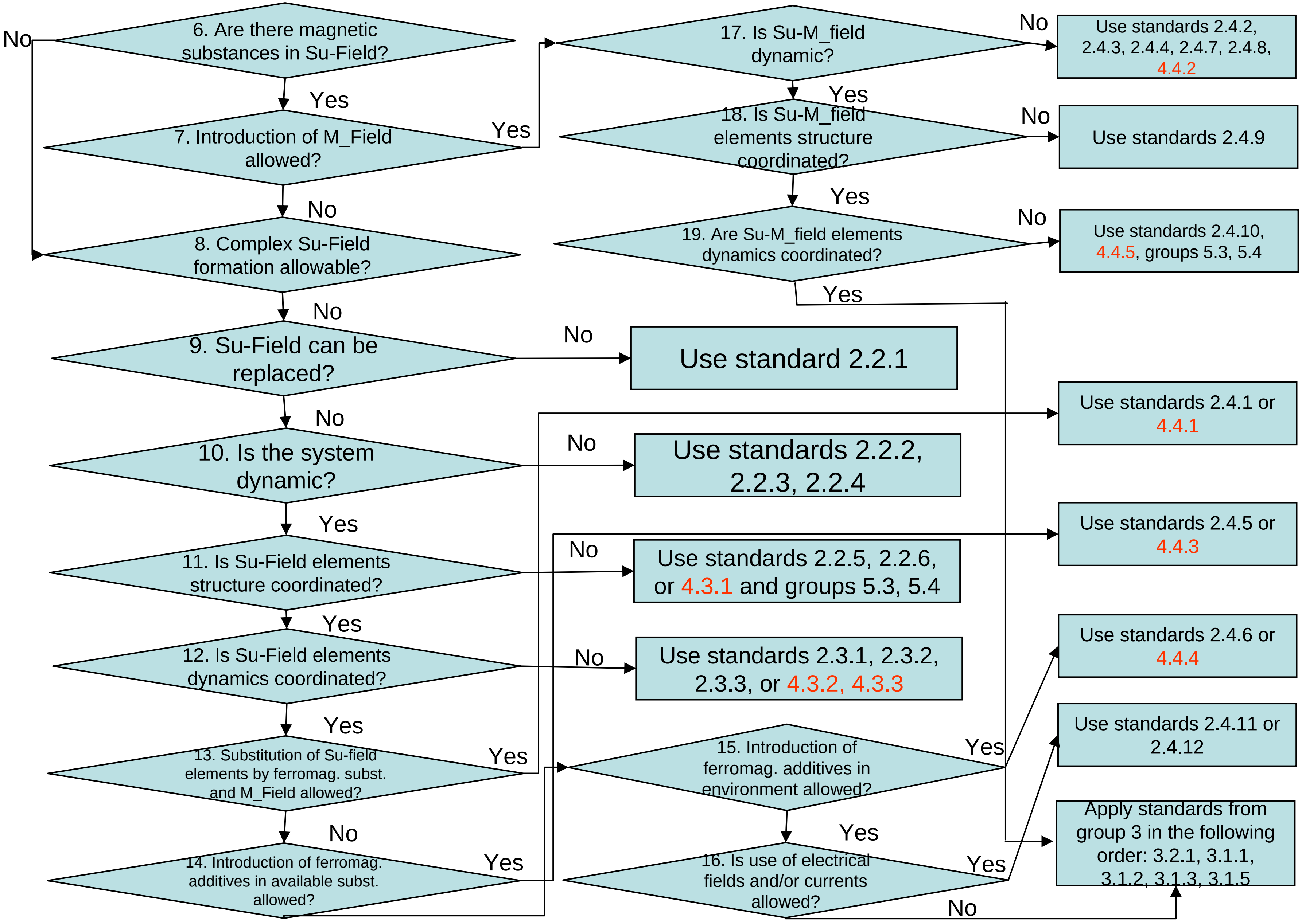


Example: Standard 4-3-1

- If we are given the problem of measurement and the problem cannot be changed to remove the need for measurement, and it is impossible to use copies or pictures, it is proposed to transform this problem into the a problem of successive detection of changes.
- *Example: To measure temperature, it is possible to use a material that changes its color depending on the current value of the temperature. Alternatively, several materials can be used to indicate different temperatures.*
  - *Uses color as a surrogate measurement.*

SFM Algorithm

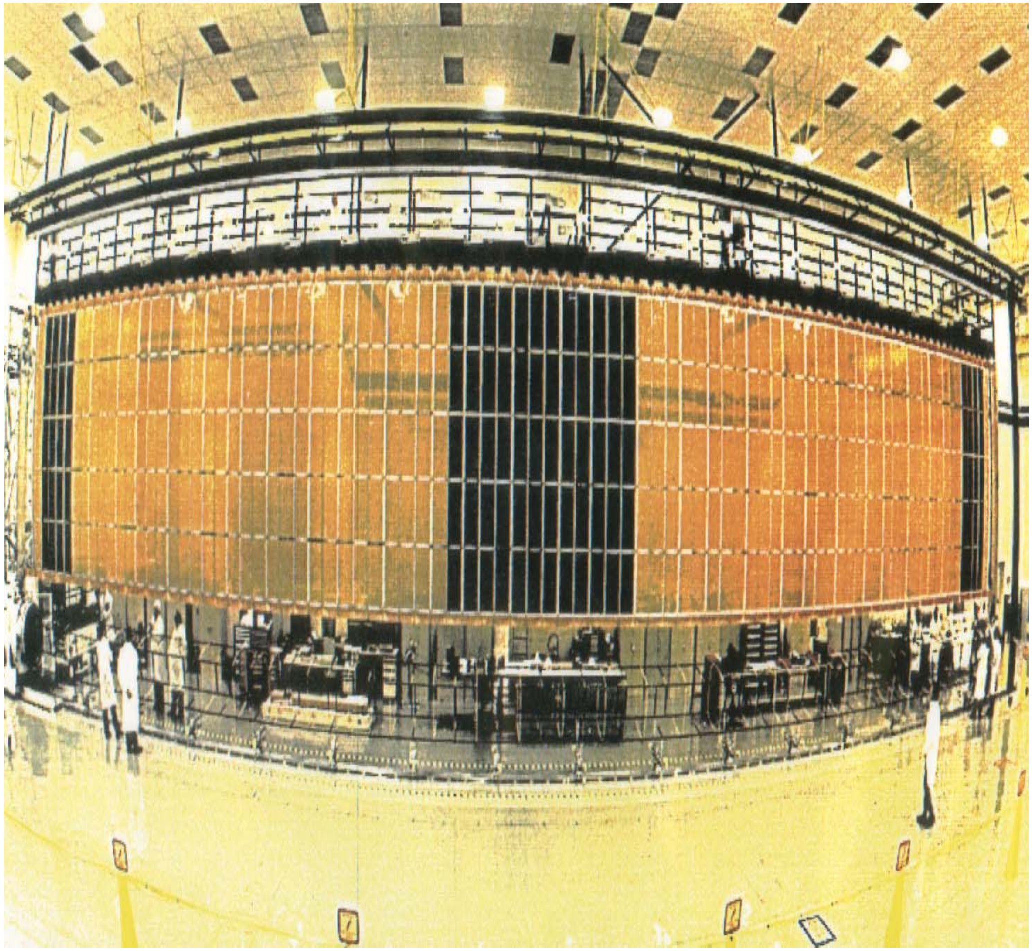




6. Are there magnetic substances in Su-Field?
No
Yes
7. Introduction of M_Field allowed?
Yes
No
8. Complex Su-Field formation allowable?
No
9. Su-Field can be replaced?
No
Use standard 2.2.1
No
10. Is the system dynamic?
No
Use standards 2.2.2, 2.2.3, 2.2.4
Yes
11. Is Su-Field elements structure coordinated?
No
Use standards 2.2.5, 2.2.6, or 4.3.1 and groups 5.3, 5.4
Yes
12. Is Su-Field elements dynamics coordinated?
No
Use standards 2.3.1, 2.3.2, 2.3.3, or 4.3.2, 4.3.3
Yes
13. Substitution of Su-field elements by ferromag. subst. and M_Field allowed?
Yes
No
14. Introduction of ferromag. additives in available subst. allowed?
Yes
15. Introduction of ferromag. additives in environment allowed?
Yes
16. Is use of electrical fields and/or currents allowed?
Yes
No
17. Is Su-M_field dynamic?
No
Use standards 2.4.2, 2.4.3, 2.4.4, 2.4.7, 2.4.8, 4.4.2
Yes
18. Is Su-M_field elements structure coordinated?
No
Use standards 2.4.9
Yes
19. Are Su-M_field elements dynamics coordinated?
No
Use standards 2.4.10, 4.4.5, groups 5.3, 5.4
Yes
Use standards 2.4.1 or 4.4.1
Use standards 2.4.5 or 4.4.3
Use standards 2.4.6 or 4.4.4
Use standards 2.4.11 or 2.4.12
Apply standards from group 3 in the following order: 3.2.1, 3.1.1, 3.1.2, 3.1.3, 3.1.5

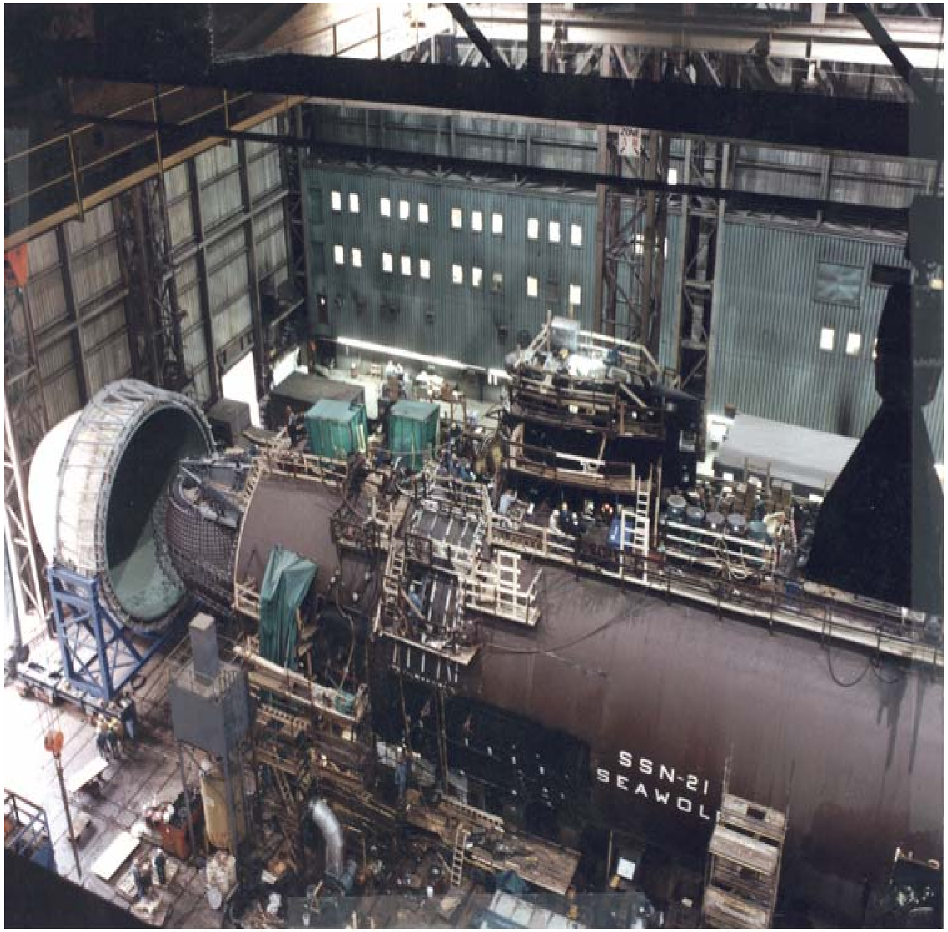
No

ISS Solar Panel Array



SFM was used to create solutions for surface imperfection problems in the ISS Solar Panel Array

SeaWolf Submarine



SFM was used extensively throughout the development of the fore and aft passive sonar arrays

Cassini-Huygens Satellite

SFM was used in many cases to help understand complex system interactions and create isolation systems for the Huygens Probe

Conclusions

- SFM is a powerful method of understanding a system and all interactions
- SFMs that contain defects may be solved using the 76 Standards
- The SFM Algorithm simplifies standard selection
- SFM Theory may be learned as part of an Advanced TRIZ curriculum

You can learn more at:

www.realinnovation.com

www.triz-journal.com

www.inventioneeringco.com and www.airacad.com

Class 4 – Measurement and Detection Standards

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-1

If a problem involves detection or measurement, it is proposed to change the problem in such a way, so that there should be no need to perform detection of measurement at all.

Example: To prevent a permanent electric motor from overheating, its temperature is measured by a temperature sensor. If to make the poles of the motor of an alloy with a Curie point equal to the critical value of the temperature, the motor will stop itself.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-2

If a problem involves detection of measurement, and it is impossible to change the problem to eliminate the need for detection or measurement, it is proposed to change/detect properties of a copy of the object (e.g. picture).

Example: It might be dangerous to measure the length of a snake. It is safe to measure its length on a photographic image of the snake, and then recalculate the obtained result.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-3

If a problem involves detection or measurement, and the problem cannot be changed to eliminate the need for measurement, and it is impossible to use copies or pictures, it is proposed to transform this problem into a problem of successive detection of changes.

Notes: Any measurement is conducted with a certain degree of accuracy. Therefore, even if the problem deals with continuous measurement, one can always single out a simple act of measurement that involves two successive detections. This makes the problem much simpler.

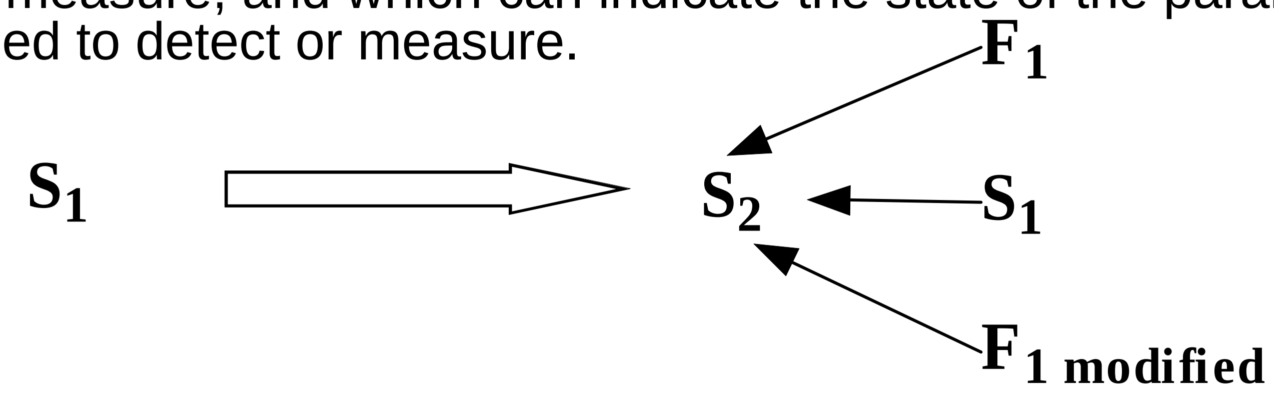
Example: To measure a temperature, it is possible to use a material that changes its color depending on the current value of the temperature. Alternatively, several materials can be used to indicate different temperatures.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

STANDARD 4-2-1

If a non-SFM is not easy to detect or measure, the problem is solved by synthesizing a simple or dual SFM with a field at the output. Instead of direct measurement or detection of a parameter, another parameter identified with the field is measured or detected. The field to be introduced should have a parameter that we can easily detect or measure, and which can indicate the state of the parameter we need to detect or measure.



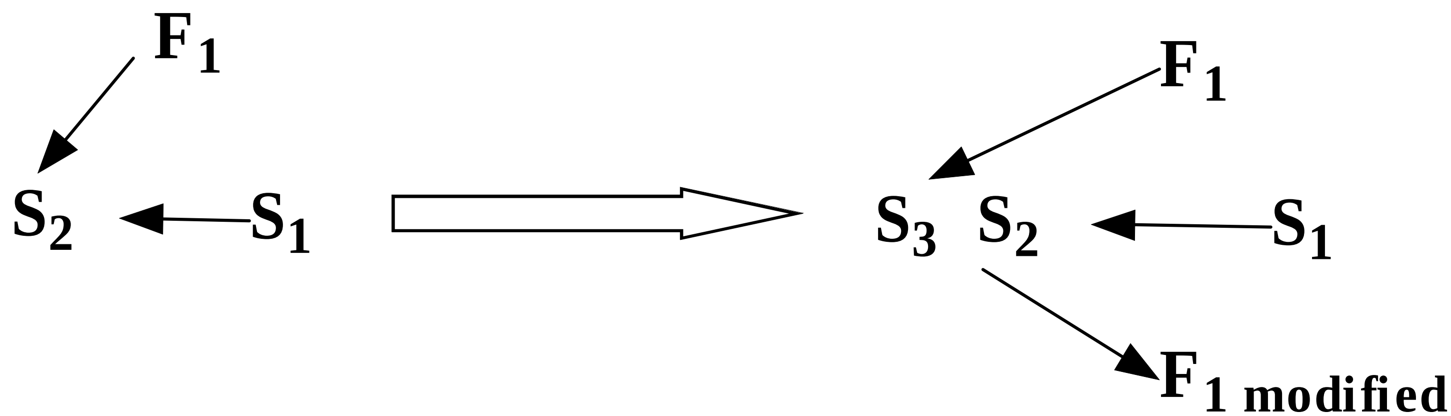
Example: To detect a moment when liquid starts to boil, an electrical current is passed through the liquid. During boiling, air bubbles are formed - they dramatically reduce electrical resistance of the liquid.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

STANDARD 4-2-2

If a system (or its part) does not provide detection or measurement, the problem is solved by transition to an internal or external complex measuring SFM, introducing easily detectable additives.



Example: To detect leakage in a refrigerator, a cooling agent is mixed with a luminescent powder.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

<u>STANDARD 4-2-3</u>

If a system is difficult to detect or to measure at a given moment of time, and it is not allowed or not possible to introduce additives into the object, then additives that create an easily detectable and measurable field should be introduced in the external environment. Changing the state of the environment will indicate the state of the object.

Example: To detect wearing of a rotating metal disc contacting with another disc, it is proposed to introduce luminescent powder into the oil lubricant, which already exists in the system. Metal particles collecting in the oil will reduce luminosity of the oil.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

<u>STANDARD 4-2-4</u>

If it is impossible to introduce easily detectable additives in the external environment, these can be obtained in the environment itself, for instance, by decomposing the environment or by changing the aggregate state of the environment.

<u>Notes:</u> In particular, gas or vapor bubbles produced by electrolysis, cavitation or by any other method may often be used as additives obtained by decomposing the external environment.

Example: The speed of a water flow in a pipe might be measured by amount of air bubbles resulting from cavitation.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-3: Improvement of Measurement Systems

STANDARD 4-3-1

Efficiency of measuring SFM can be improved by the use of physical effects.

Example: Temperature of liquid media can be measured by measuring a change of a coefficient of retraction, which depends on the value of the temperature.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-3: Improvement of Measurement Systems

STANDARD 4-3-2

If it is impossible to detect or measure directly the changes in the system, and no field can be passed through the system, the problem can be solved by exciting resonance oscillations (of the entire system or of its part), whose frequency change is an indication of the changes taking place.

Example: To measure the mass of a substance in a container, the container is subjected to mechanically forced resonance oscillations. The frequency of the oscillations depends on the mass of the system.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-3: Improvement of Measurement Systems

STANDARD 4-3-3

If resonance oscillations may not be excited in a system, its state can be determined by a change in the natural frequency of the object (external environment) connected with the system.

Example: The mass of boiling liquid can be measured by measuring the natural frequency of gas resulting form evaporation.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-1

Efficiency of a measuring SFM can be improved by using a ferromagnetic substance and a magnetic field.

Notes: The standard indicates the use of a non-fragmented ferromagnetic object.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-2

Efficiency of detection or measurement can be improved by transition to ferromagnetic SFMs, replacing one of the substances with ferromagnetic particles (or adding ferromagnetic particles) and by detecting or measuring the magnetic field.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-3

If it is required to improve the efficiency of detection or measurement by transition to a ferromagnetic SFM, and replacement of the substance with ferromagnetic particles is not allowed, the transition to the F-SFM is performed by synthesizing a complex ferromagnetic SFM, introducing (or attaching) ferromagnetic additives in the substance.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-4

If it is required to improve efficiency of detection or measurement by transition to F-SFM, and introduction of ferromagnetic particles is not allowed, ferromagnetic particles are introduced in the external environment.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-5

Efficiency of a F-SFM measuring system can be improved by using physical effects, for instance, Curie point, Hopkins and Barkhausen effects, magnetoelastic effect, etc.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-5: Evolution of Measurement Systems

STANDARD 4-5-1

Efficiency of a measuring system at any stage of its evolution can be improved by forming bi- and poly-system.

Notes: To form bi- and poly-systems, tow or more components are combined. The components to be combined may be substances, fields, substance-field pairs and SFMs.

Example: It is difficult to accurately measure the temperature of a small beetle. However, if there are many beetles put together, the temperature can be measured easily.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-5: Evolution of Measurement Systems

STANDARD 4-5-2

Measuring systems evolve towards measuring the derivatives of the function under control. The transition is performed along the following line:

Measurement of a function $\rightarrow$ measurement of the first derivative of the function $\rightarrow$ measurement of the second derivative of the function.

Example: Change of stress in the rock is defined by the speed of changing the electrical resistance of the rock.

UNMANNED SYSTEMS
T&E Challenges & Opportunities

Dr. James Streilein

February 2008

Agenda

- ATEC Mission
- Achieving Balance (Traditional & Rapid)
- Common Rapid Acquisition Challenges
- Unmanned Systems – ATEC Involvement
- Unmanned Systems – Unique Challenges
- T&E Opportunities

ATEC Mission:

Does it Work?

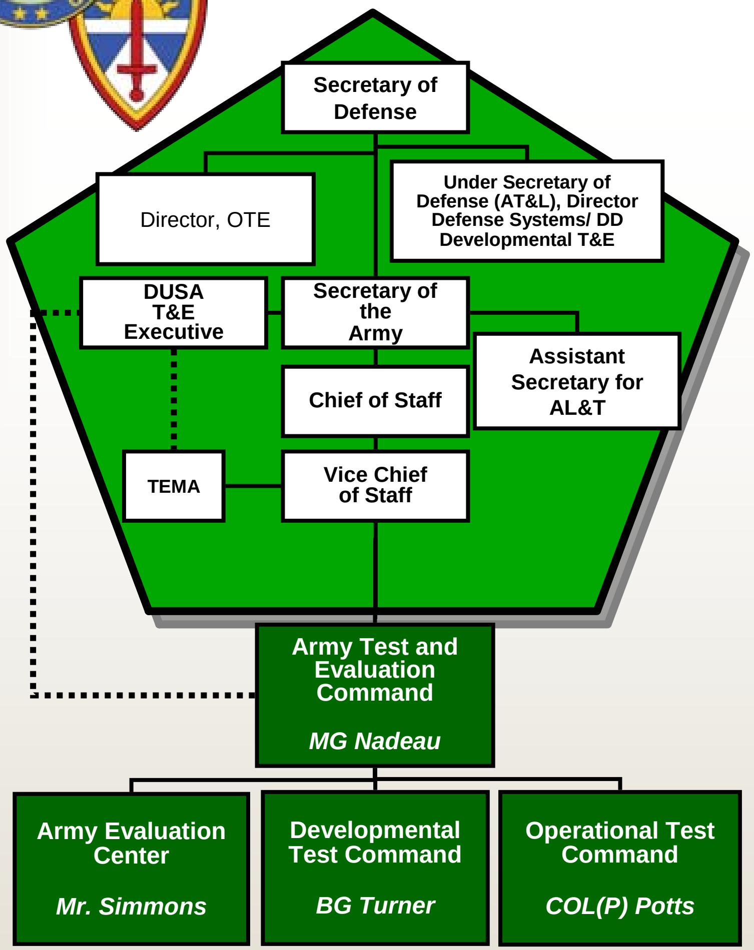
...How Do I Know?

EFFECTIVENESS **SUITABILITY** **SURVIVABILITY**

Mission Statement

- Facilitate equipment procurement/fielding decisions through testing and analysis to ensure our Army's Warfighters have the right capabilities for success across the entire spectrum of operations.
- Conduct rapid testing in direct support of the Global War on Terror, providing capabilities and limitations analyses of weapon systems to enable employment decisions for rapid fielding to the Combat Soldier.

How We Fit



Legend

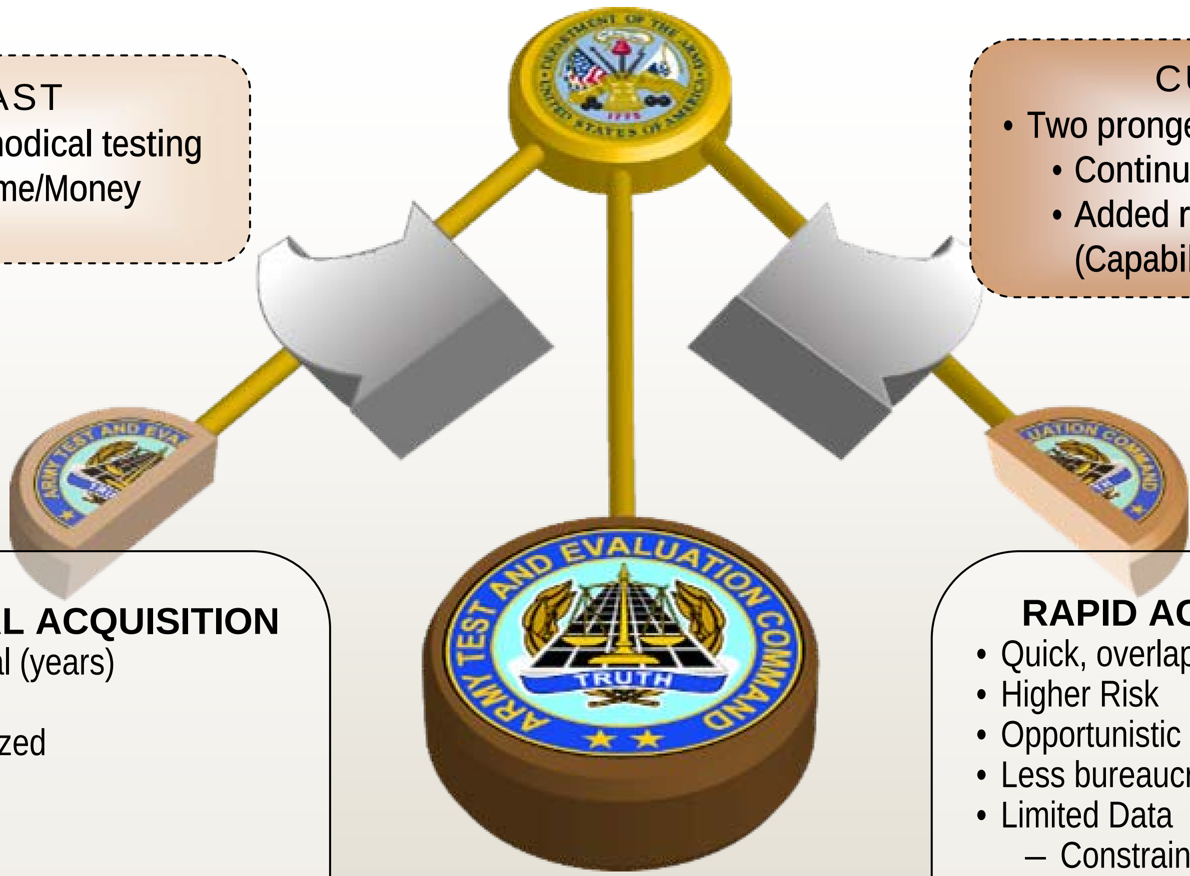
.... T&E Policy and Oversight

Independent Reporting Mandated by US Code, OMB, and OSD

Achieving Balance

PAST
- Strong methodical testing
- Requires Time/Money

CURRENT
- Two pronged
  - Continue traditional testing
  - Added rapid testing (Capabilities & Limitations)



TRADITIONAL ACQUISITION
- Slow, sequential (years)
- Risks Mitigated
- Fully Synchronized
- Bureaucratic
- All data
  - Robust DT
  - Full OT
- Expensive

FUTURE

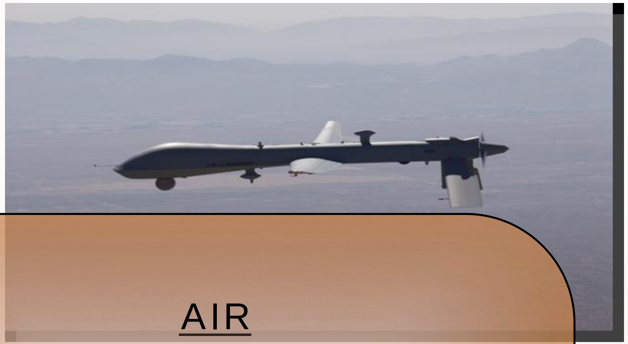
A different degree of "normalcy"
- What is it?
- Where does it apply?

RAPID ACQUISITION
- Quick, overlapping (months)
- Higher Risk
- Opportunistic
- Less bureaucratic
- Limited Data
  - Constrained DT
  - Limited OT
  - C&L Report to User
- Less Expensive
- Relatively Fast

Common Rapid Acquisition Challenges

- **Requirements are technology-driven vice user-driven**
  - **Often unclear concept of operations**
- **Reliance on contractor test data and informal unit feedback**
  - **Unknown COTS suitability for operational environmental conditions**
- **Immature system supportability considerations prior to deployment**
  - **Indefinite contractor logistics support**

Unmanned Systems
Wide ATEC Involvement



AIR

- ER/MP (Extended Range/Multi-Purpose)
- FCS Class I (MAV Heavy Fuel)
- FCS Class IV (Fire Scout)
- Joint Tactical UAS (Hunter)
- Small UAS (Raven)
- Tactical UAS (Shadow)
- Warrior A

- GMAV (Gas Micro Air Vehicle)
- Telluride

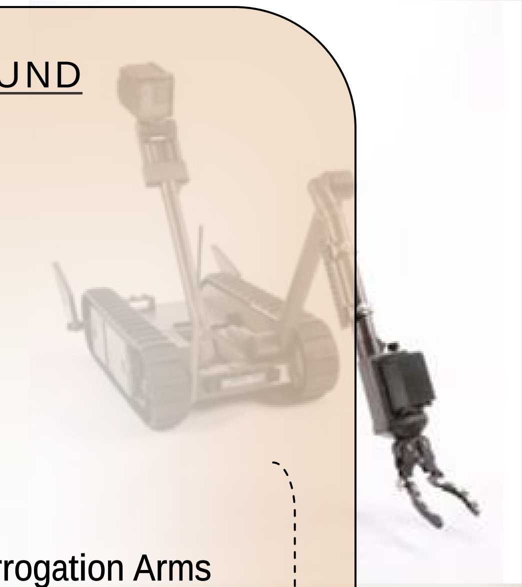
Rapid Acquisition

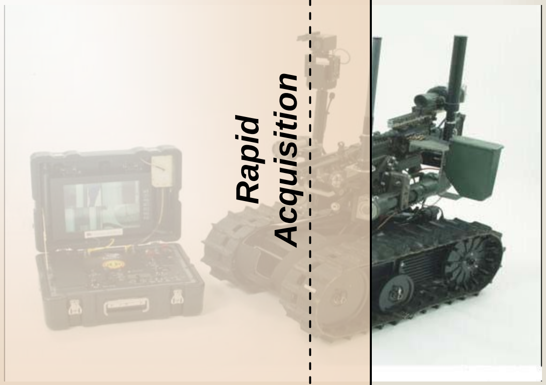
GROUND

- FCS Small UGV
- IMS
- LKMD
- MDAR
- Outpost
- SWORDS
- Spider NMS

- ANDROS Robot
- Concorde
- Husky & RG-31 Interrogation Arms
- MV-4 Mine Roller
- LVUSS Robot
- MARCBot
- Mini-EOD Robot
- ODIS
- Pipe Robots
- Rabbit
- Routerunner
- Talon 3B
- Tactibot / Throwbot / Toughbot
- xBot (PackBot FasTac)

Rapid Acquisition





Unmanned Systems
Unique Challenges

- **Increased operator workload**
  - **Manning & organization considerations**
  - **Balancing manned and unmanned system tasks**
  - **Remote spatial orientation**
- **Complex supportability considerations**
  - **Remote condition monitoring**
  - **Self-recovery and transportability**
  - **Mission creep increases logistics burden**

Unmanned Systems
Unique Challenges

- **Weaponized robots**
  - **“Fail-safe” design required for system safety**
  - **Reliability dependent on software & command link**
  - **Rapid target detection/identification needed**
- **System-of-system interoperability**
  - **Airspace management**
  - **Spectrum management**
  - **Network management**

T&E Opportunities

- **Aid requirements and system development**
  - **T&E community has enduring, diverse knowledge**
- **Integrated contractor/government testing**
  - **Learn early; test within operational context; minimize duplication**
- **Forward Operational Assessment Team**
  - **Feedback loop for system changes or updates to employment considerations & TTPs**
- **Mission-based T&E**
  - **System contribution to mission accomplishment**

TEST & EVALUATION

A Critical Enabler to Capabilities-Based Acquisition

Dr. James Streilein
Technical Director, ATEC
james.streilein@us.army.mil
703-681-9365

GENERAL DYNAMICS
Land Systems

Application of MIL-HDBK-189 Reliability Growth Analysis (RGA) on Mobile Gun System (MGS) Product Verification Test (PVT)

Sharad Kumar, Senior Director, System Engineering
John Paulson, Director, Stryker Program
Dmitry E. Tananko, Ph.D., Manager, Reliability and Robust Engineering
Jenny Chang, PM SBCT, TACOM

Agenda

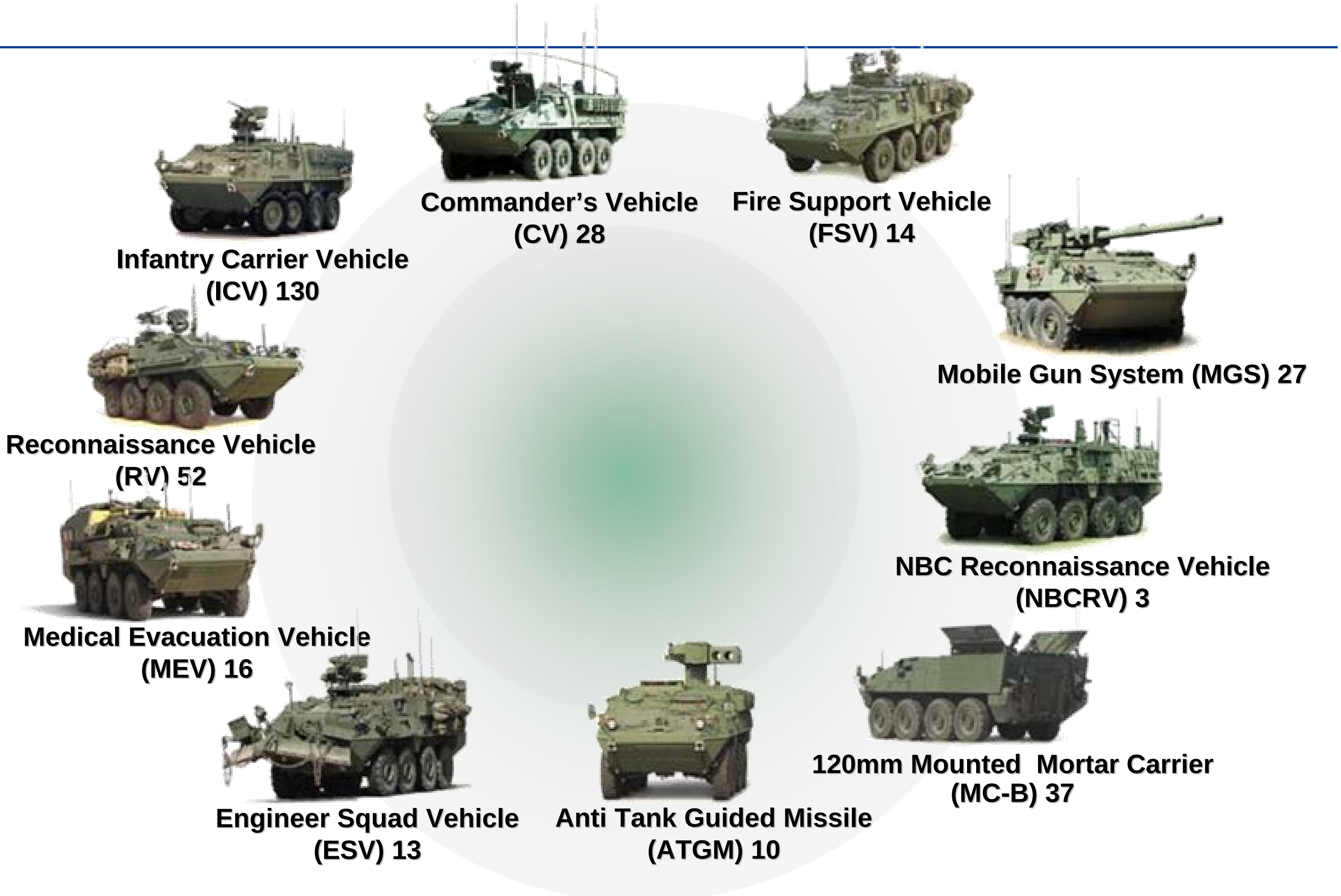
- **What is MGS**
- **Success Factors of MGS PVT**
  - ➢ Program Management – Integrated Team
  - ➢ System Engineering and Reliability Attainment
  - ➢ Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- **MGS Lesson Learned - DFR**

Agenda

- **What is MGS**
- **Success Factors of MGS PVT**
  - Program Management – Integrated Team
  - System Engineering and Reliability Attainment
  - Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- **MGS Lesson Learned - DFR**

GENERAL DYNAMICS
Land Systems

Stryker Family of Vehicles



Mobile Gun System – The Bunker Buster

GENERAL DYNAMICS
Land Systems

BLUF – Key Factors for Successful Reliability Growth Program

- **Program Management – Integrated Team**
  - The systems, tools, and practices now in place between the US Government and General Dynamics Land Systems allowed the system's reliability to grow (repeatable process)
  - Reliability growth requires commitments from Material Developer Team, Combat Developer, and Independent Test and Evaluation Communities (requirements, test, data, methodology, tools)
- **System Engineering – Reliability Backbone**
  - Integrates All Reliability Tasks
  - Redirects Tasks Toward a Single Objective
  - Crosses Boundaries Affecting Operational Reliability
  - Provides Program Manager Authority, Funding, and Focus on Engineering, Processes, Documentation, Training, Manufacturing, and Testing for Reliability
- **Reliability Data Analysis – Reliability Assessment**
  - FDSC – Failure Definition Scoring Criteria
  - Failure Categories
    - Inherent vs. Induced Reliability
  - Mission Profile and Life Variable
  - Data Grouping and Modeling
  - Instantaneous vs. Cumulative Reliability

Agenda

- **What is MGS**
- **Success Factors of MGS PVT**
  - Program Management – Integrated Team
  - System Engineering and Reliability Attainment
  - Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- **MGS Lesson Learned - DFR**

MGS Program Management

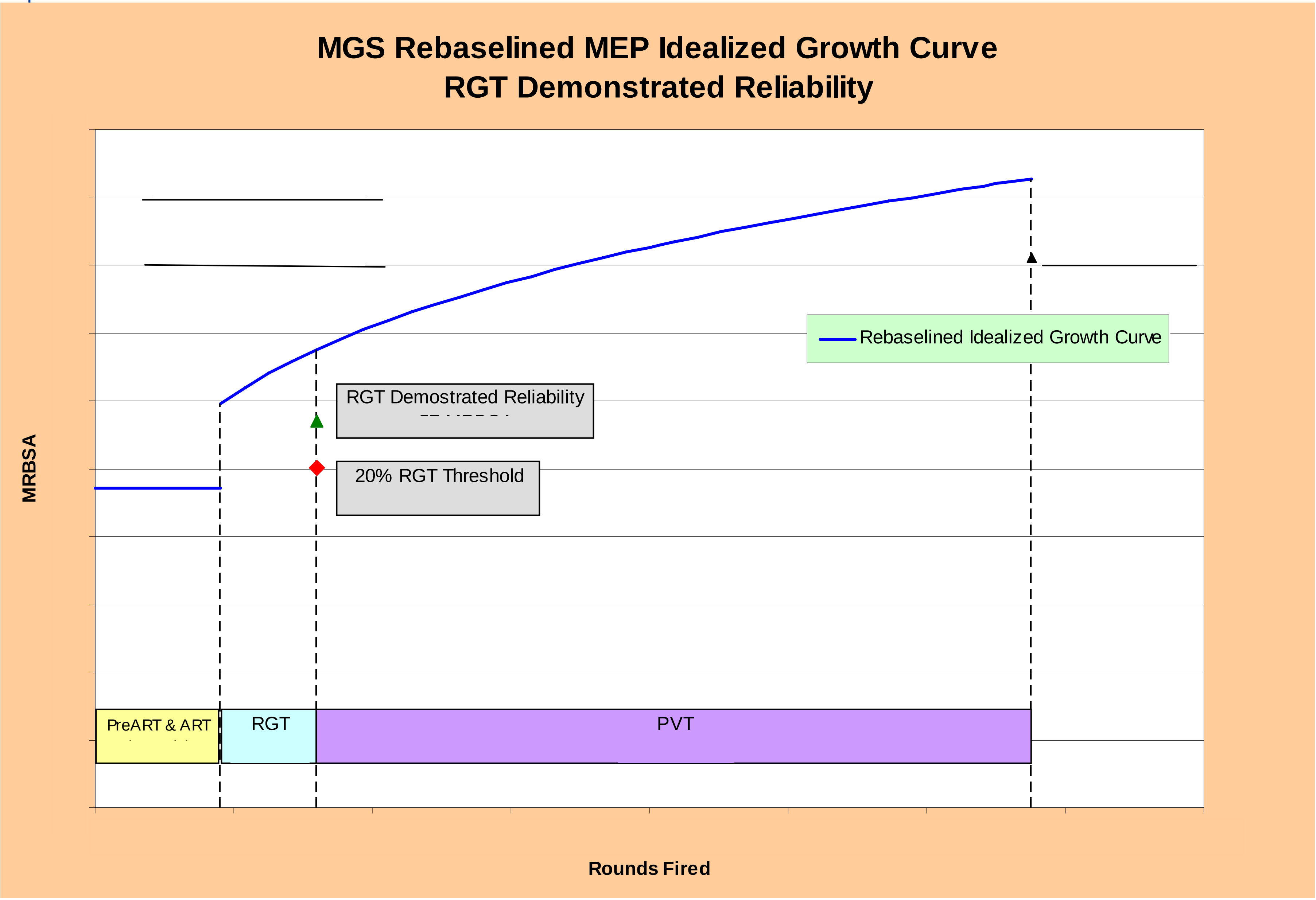
Plan

- Phase I - Conduct an Additional Reliability Test (ART)
  - Validate effectiveness of 216 PQT and Post-PQT corrective actions
- Phase II - Implement changes to Government and GDLS Systems Engineering Processes
  - Management and process changes
- Phase III - Redesign of Sub-System components and integration

Tests

- Additional Reliability Testing (DEC 2004 – MAR 2005)
  - 2 vehicles
  - Pre-ART – XXX rounds & X00 miles
  - ART – XXX rounds & X,000 miles
  - Reliability Point Estimate XX MRBSA
- Reliability Growth Test (JUL-AUG 2005)
  - 2 Vehicles
  - XXX rounds
  - X,000 miles
  - Reliability Point Estimate XX MRBSA
- Production Verification Testing (APR 2006 - DEC 2007)
  - 3 Vehicles
  - XXXX rounds
  - XX,000 miles
  - On-going – Current estimate XXX MRBSA

MGS Idealized Growth Curve



Approved for Public Release, Distribution Unlimited, GDLS approved, log 2008-04, dated 02/11/08.

Agenda

- **What is MGS**
- **Success Factors of MGS PVT**
  - Program Management – Integrated Team
  - System Engineering and Reliability Attainment
  - Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- **MGS Lesson Learned - DFR**

MGS - Systems Engineering Approach

- Integrates All Reliability Tasks
- Redirects Tasks Toward a Single Objective
- Crosses Boundaries Affecting Operational Reliability
- Provides Program Manager Authority, Funding, and Focus on Engineering, Processes, Documentation, Training, Manufacturing, and Testing for Reliability
- Approach Provides Metrics that can be Measured

SE Approach to Reliability

Increase Design Effectiveness Using Robust Design Methodology

Manage Growth Potential

Potential MTBF

Modeling
Allocation
Prediction
FMEA
Parts Program
FRACAS
Failure Prevention & & Review Board
Verification

Increase Initial MTBF

Higher Initial MTBF At Start Of Test

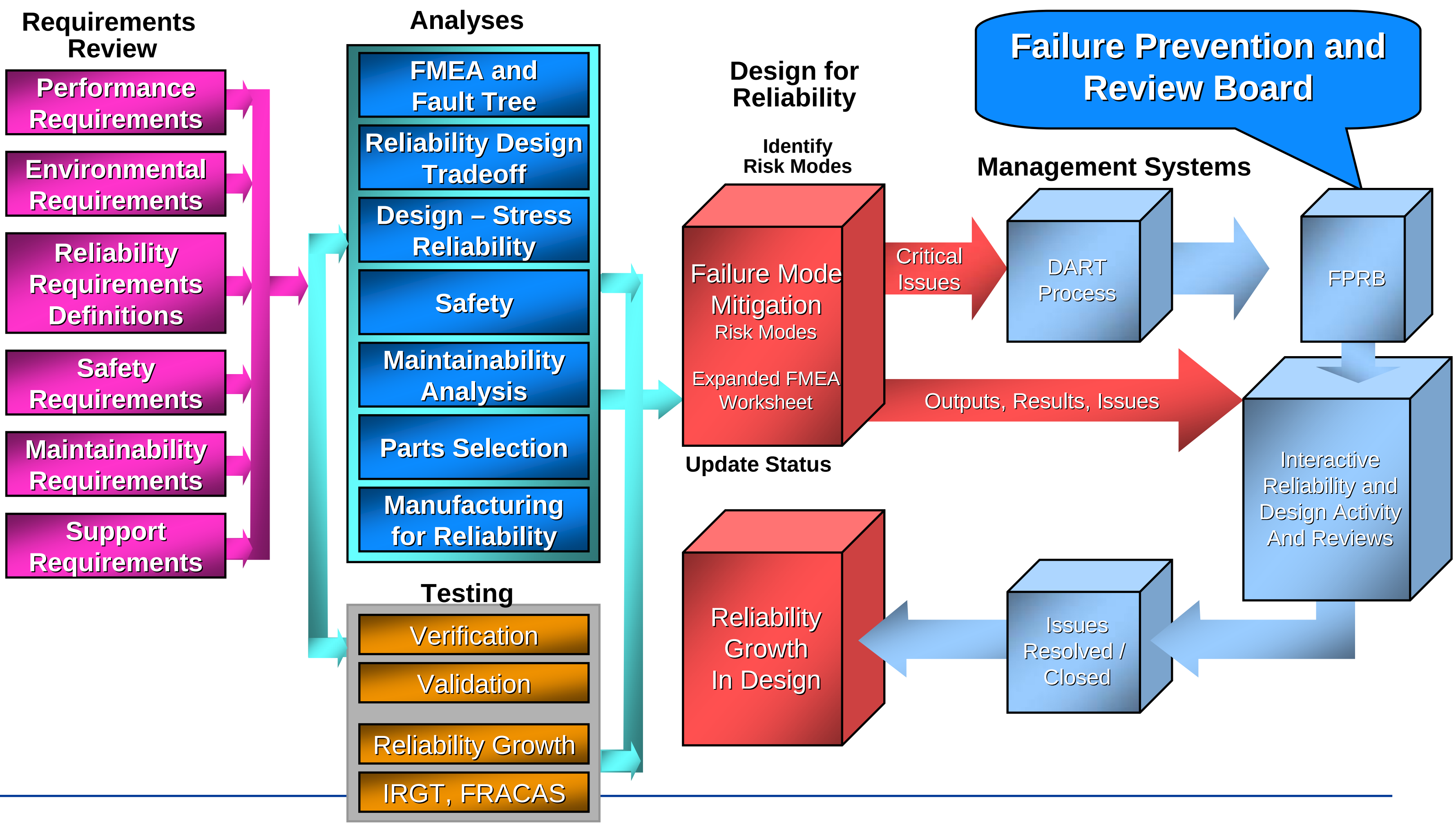
Failure Prevention
Failure Categorization
Timely Corrective Actions

Design Phase

RG/DT

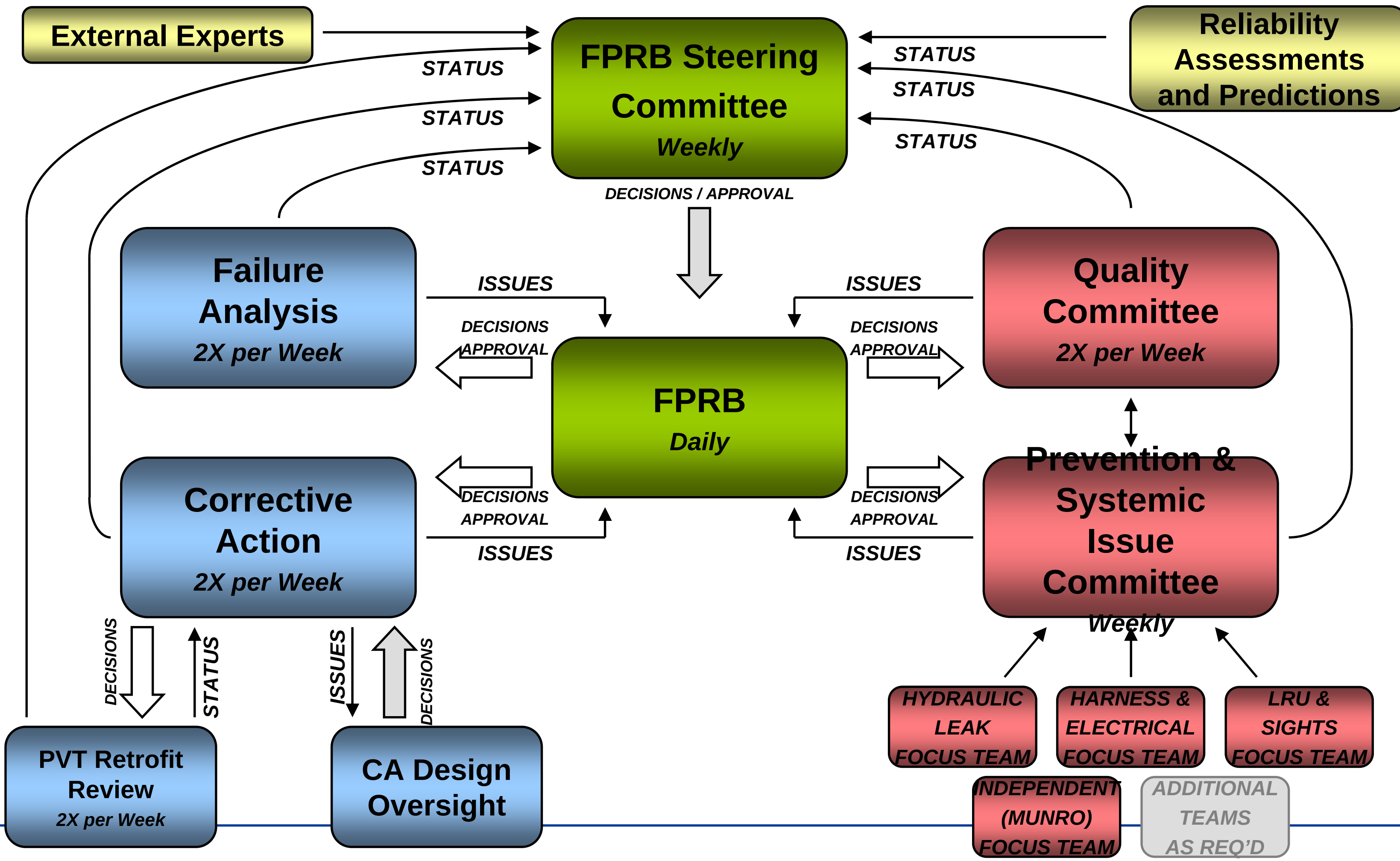
GENERAL DYNAMICS
Land Systems

Design for Reliability Management Focuses on Failure Prevention



GENERAL DYNAMICS
Land Systems

Stryker – Mobile Gun System
Failure Prevention and Resolution Implementation



GENERAL DYNAMICS
Land Systems

Agenda

- What is MGS
- **Success Factors of MGS PVT**
  - Program Management – Integrated Team
  - System Engineering and Reliability Attainment
  - Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- MGS Lesson Learned - DFR

Reliability Data Analysis

- Proper Reliability Assessment is a key for the program success at PVT
- Reliability Assessment must be discussed up front and consensus should be reached on:
  - FDSC – Failure Definition Scoring Criteria
  - Failure Categories
    - Inherent vs. Induced Reliability
  - Mission Profile and Life Variable
  - Data Grouping and Modeling
  - Instantaneous vs. Cumulative Reliability

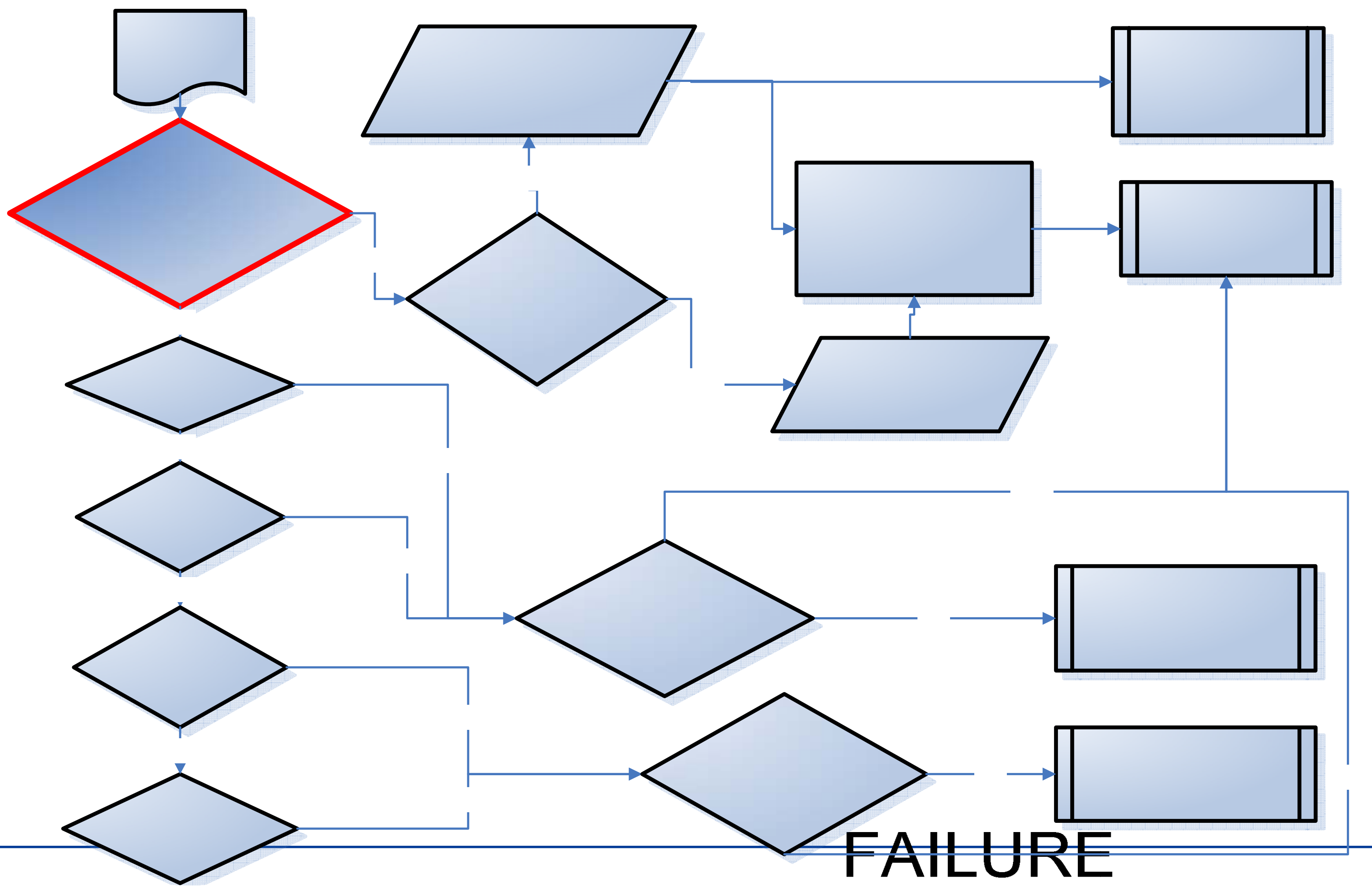
FDSC – Failure Definition Scoring Criteria

- FDSC is Contractual Document that defines
  - ➢ Failure/non-Failure Event
  - ➢ Test related Event
  - ➢ Severity of Failure as it relates to the Mission
  - ➢ Cause of the Failure
- FDSC is prepared as required by Army Regulation 70-1, Army Acquisition Policy.
- FDSC is being used through out the test for Scoring purposes, hence it is a major document for Reliability Assessment

Failure Categories

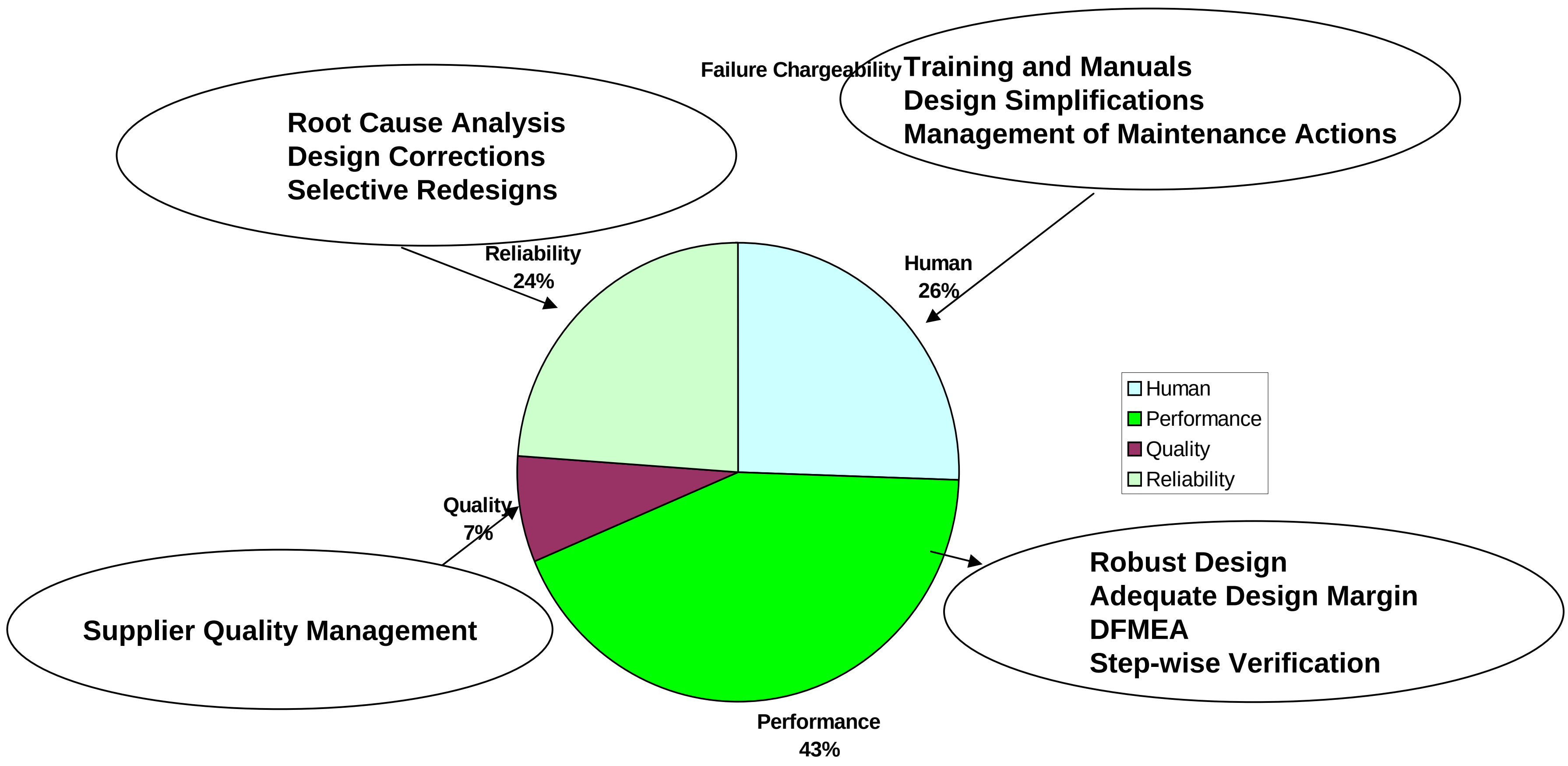
- Performance FM – FM is repeatable with 100% probability of failure for the given procedure/conditions. (Example: TDS overheating)
- Software FM – same as above, but software related.
- Quality FM – happens when vehicle is not built/maintained/operated as designed and is not repeatable after fixing (probability of failure =0%). Can be broken down into Initial Quality, Maintenance, Operator error, etc. (Example: Improperly installed harness, turret lock bended, etc.)
- Potential Reliability FM – happens when vehicle was built/maintained/operated as designed/intended; probability of failure is greater than 0% and less than 100%; usually happens due to wear out, environment, insufficient design, manufacturing variability, etc.

Failure Mode Categorization Process
Inherent vs. Induced Failure



GENERAL DYNAMICS
Land Systems

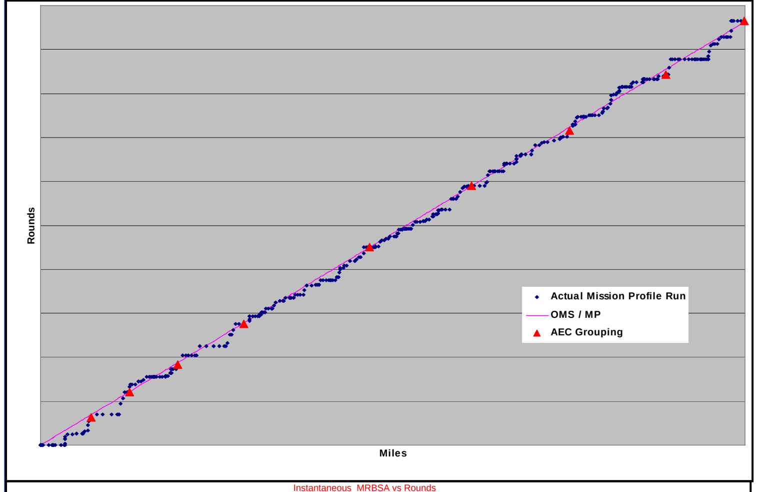
Categorize Failures and take Relevant Management Actions

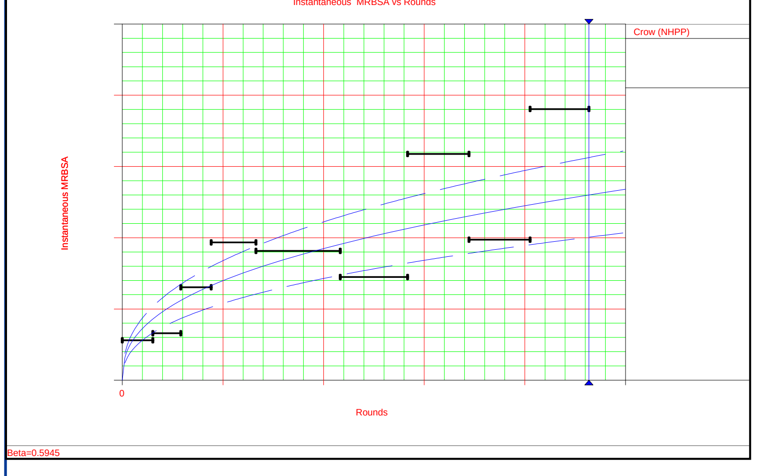


GENERAL DYNAMICS
Land Systems

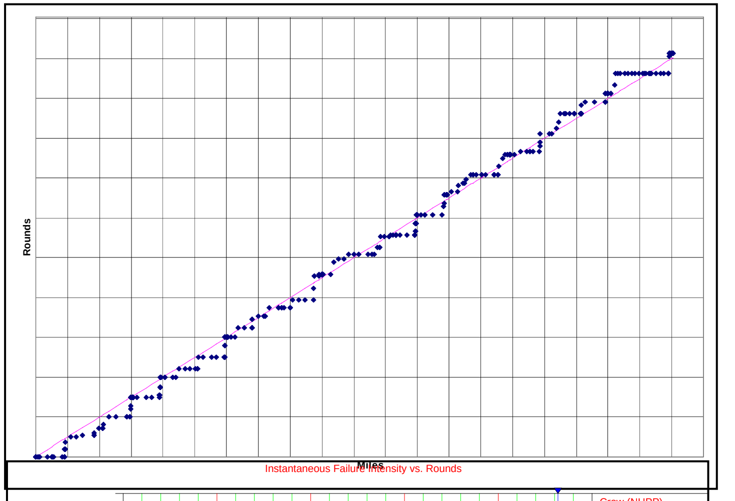
Data Grouping

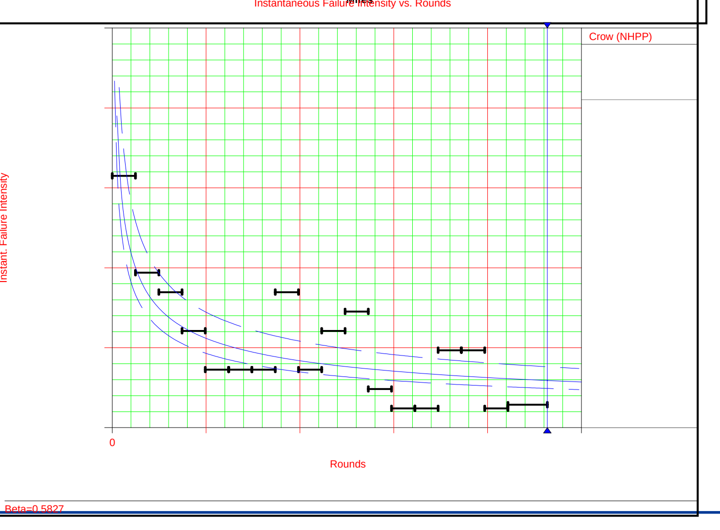
Known Equivalent Time





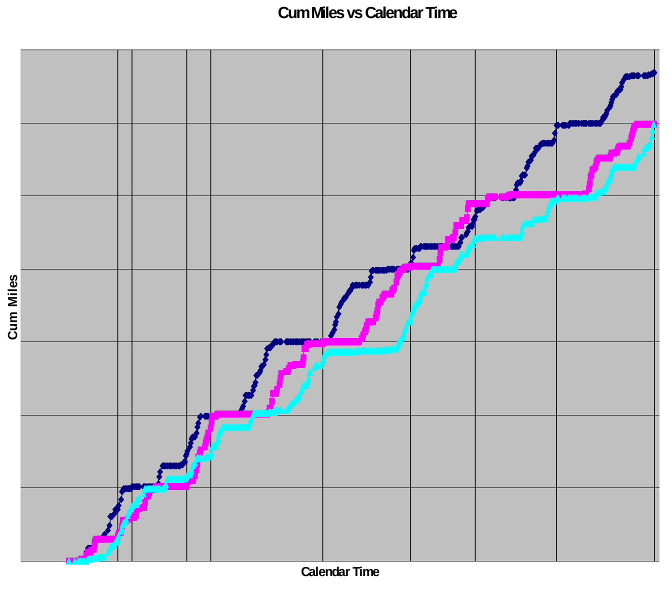
Unknown Equivalent Time



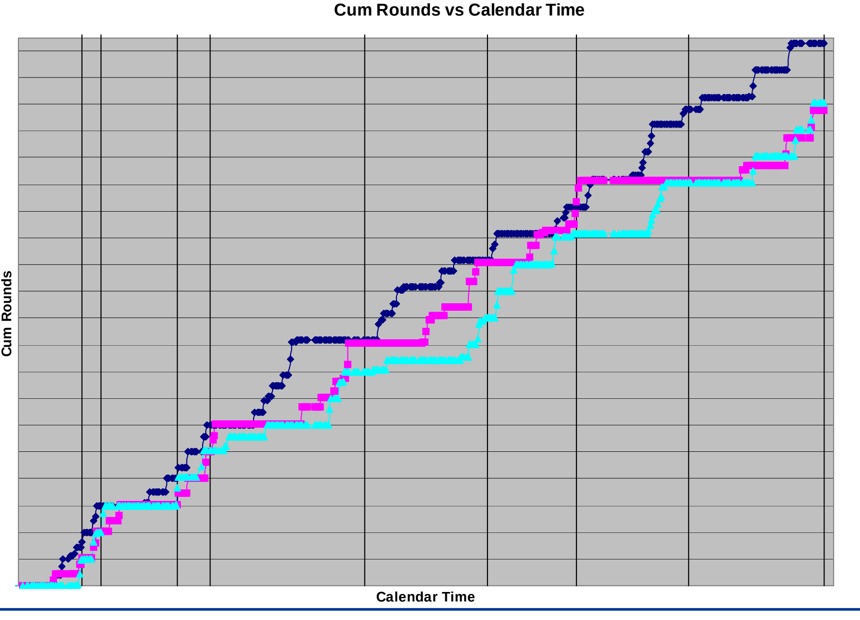


GENERAL DYNAMICS
Land Systems

Rounds and Miles Accumulation per Vehicle vs. Calendar Time



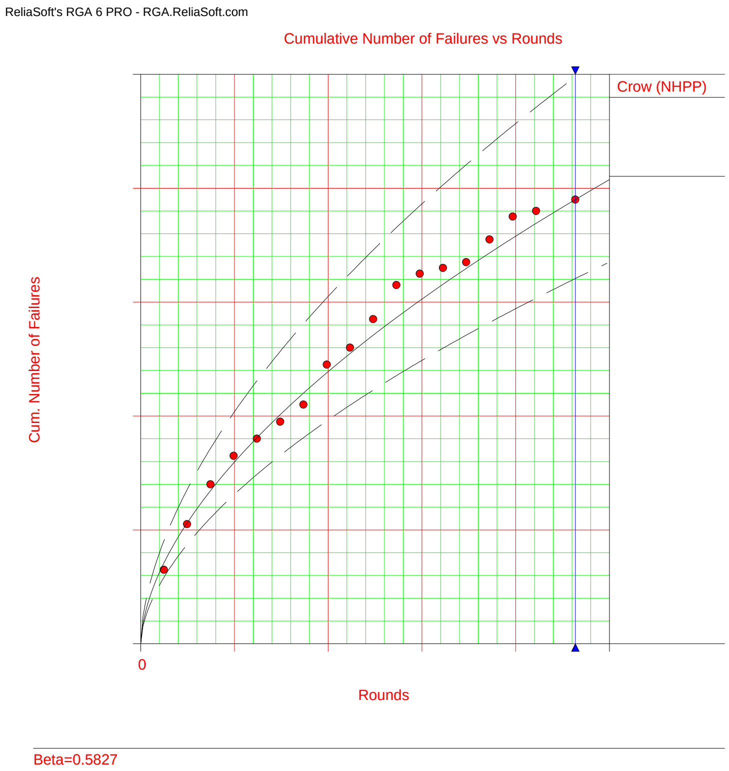
UET model takes into account any discrepancies between different vehicles following through the test in calendar time



KET Model can be useful in the beginning of the test when vehicles have not accumulated enough mileage and rounds.

GENERAL DYNAMICS
Land Systems

Crow/AMSAA Model



Cum Number of Failures $\boxed{E(N) = \lambda \cdot T^{\beta}}$

Cum Failure Rate $\boxed{r_c = \dfrac{E(N)}{T} = \lambda \cdot T^{\beta-1}}$

Cum MTBF $\boxed{MTBF_c = (r_c)^{-1} = \left(\lambda \cdot T^{\beta-1}\right)^{-1}}$

Inst Failure Rate

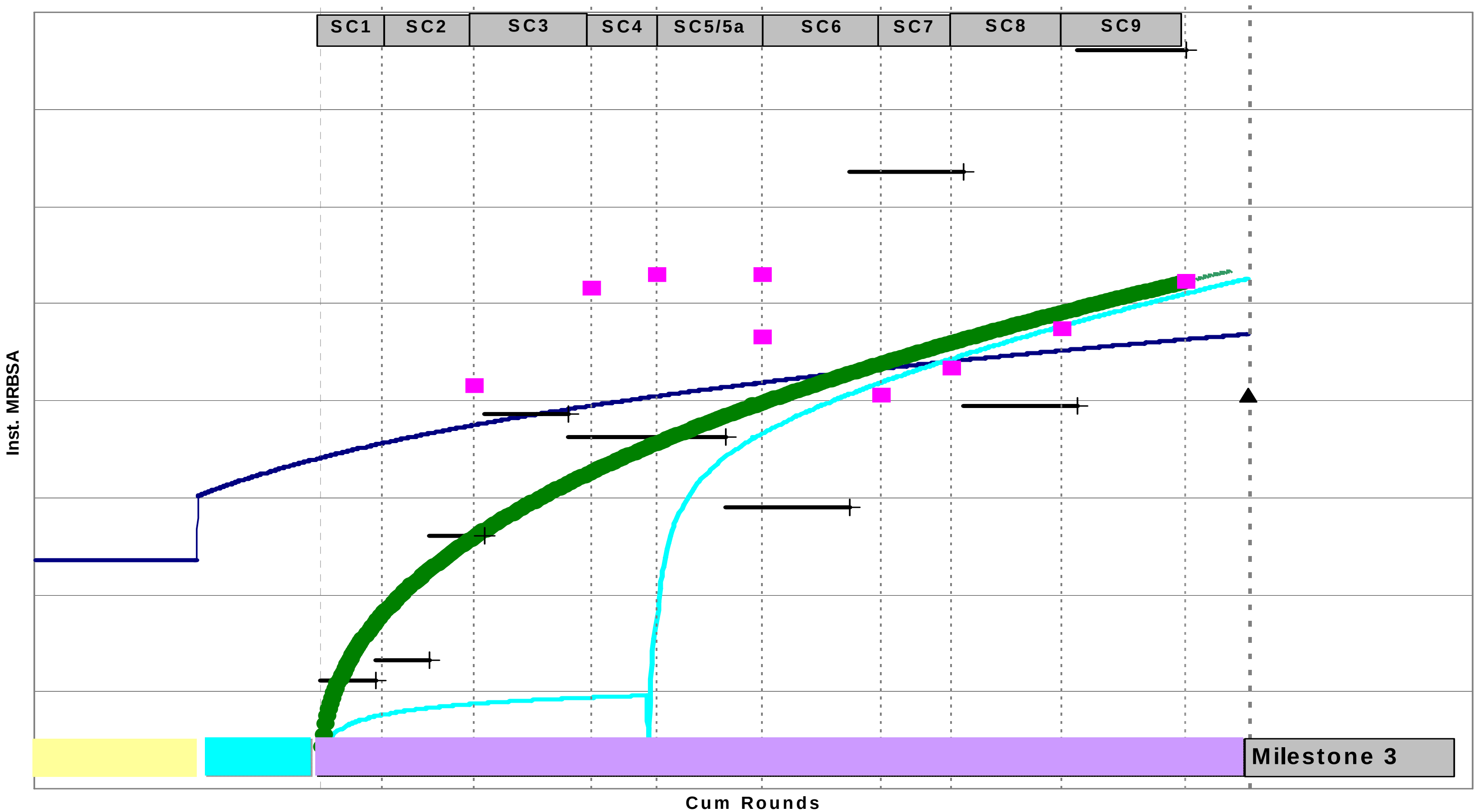
$$\boxed{r_i = \frac{d(E(N))}{dt} = \frac{d\left(\lambda \cdot t^{\beta}\right)}{dt} = \lambda \cdot \beta \cdot t^{\beta-1}}$$

Inst MTBF $\boxed{MTBF_i = (r_i)^{-1} = \left(\lambda \cdot \beta \cdot T^{\beta-1}\right)^{-1}}$

Cumulative vs. Instantaneous Reliability

- Reliability growth on the Development test is the result of Corrective Actions.
- Estimating Reliability of the product by taking the Cumulative reliability (total number of failures / total time on the test) does not take into account the growth on the test.

Idealized Growth Curve and Observed Parametric Curve for Demonstrated Instantaneous MRBSA



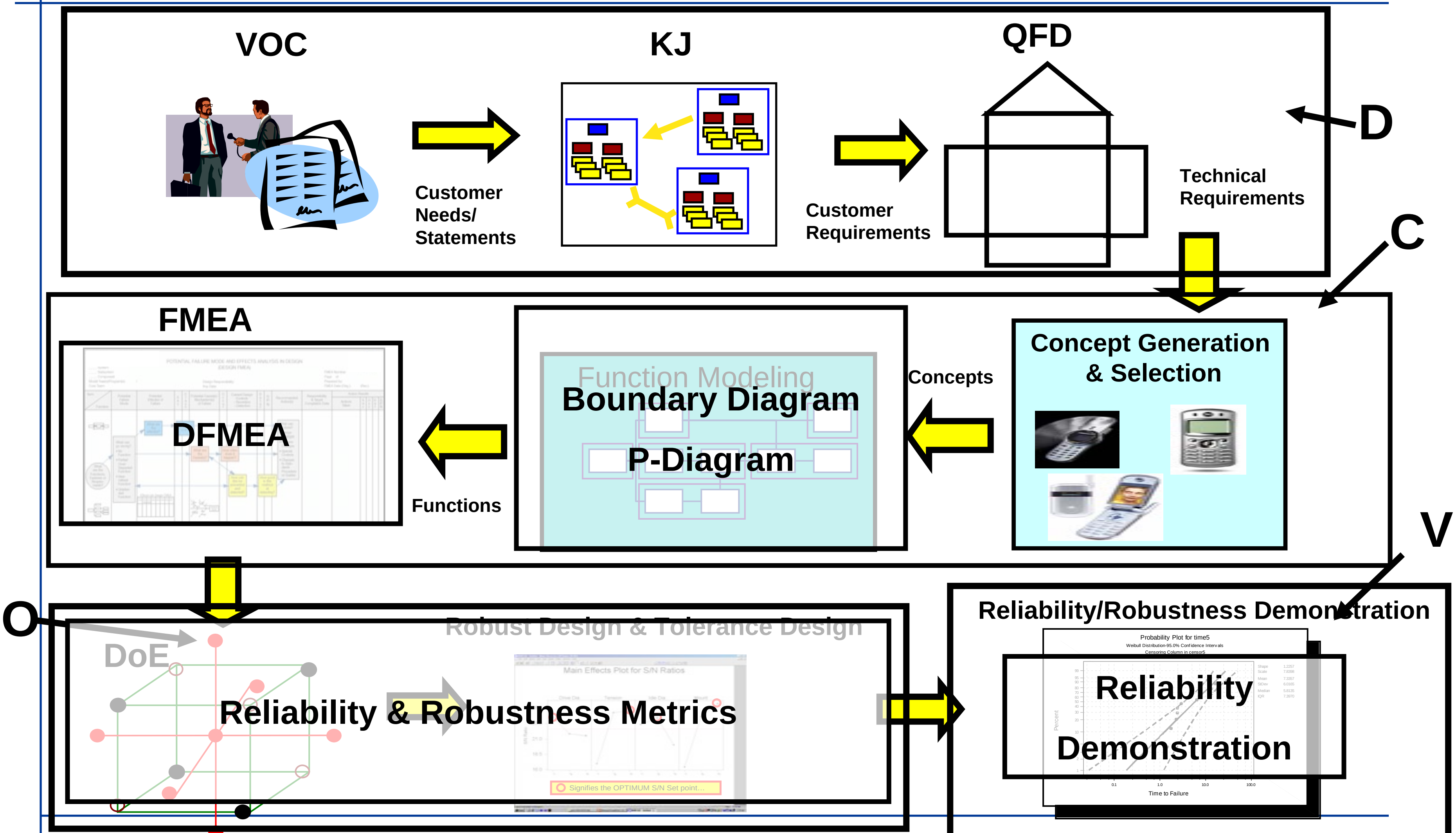
Agenda

- **What is MGS**
- **Success Factors of MGS PVT**
  - Program Management – Integrated Team
  - System Engineering and Reliability Attainment
  - Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- **MGS Lesson Learned - DFR**

DFR Process Elements

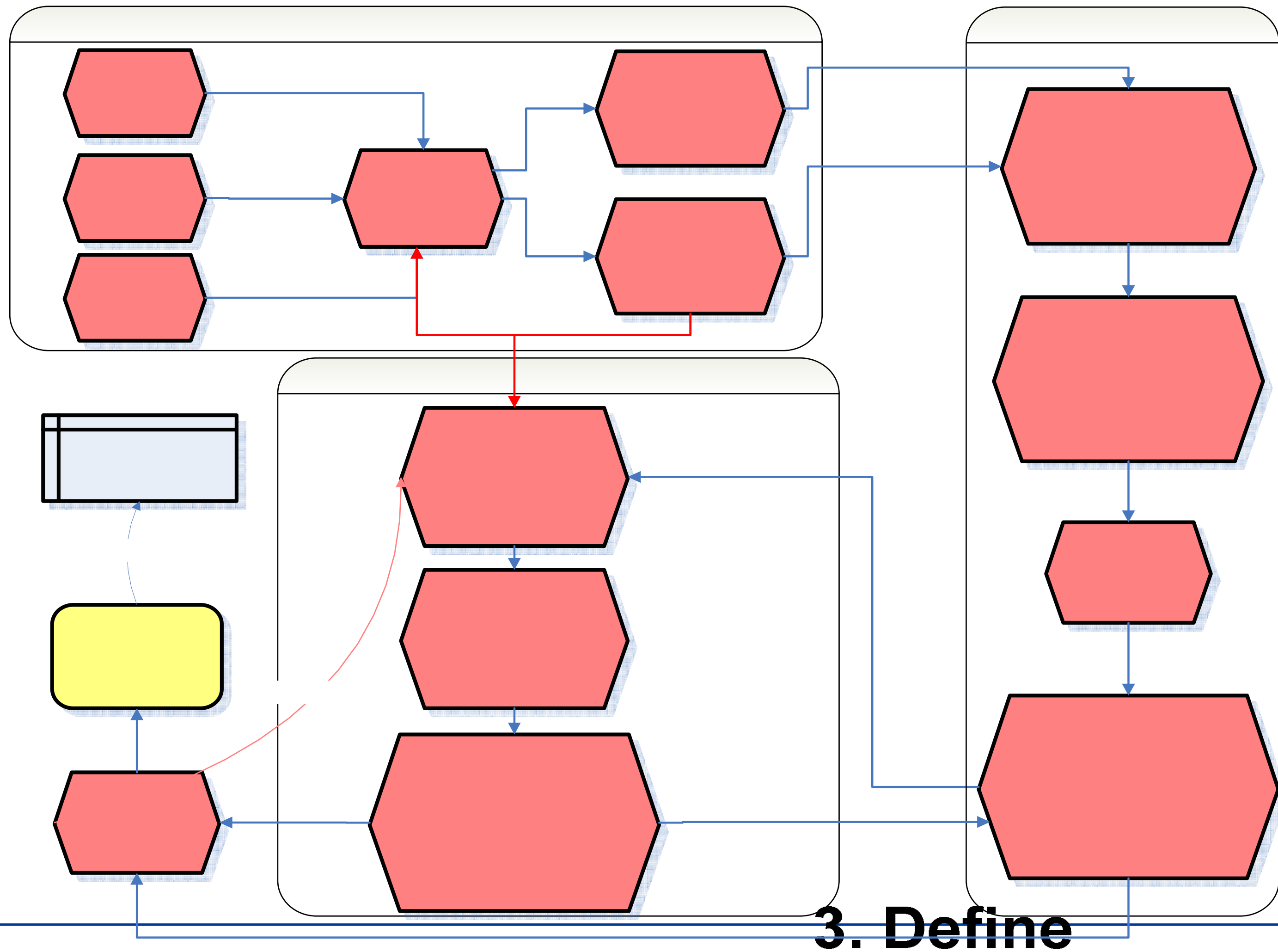
- **Boundary Diagram / System Block Diagram**
- Interface matrix
- **P-Diagram**
- **DFMEA**
- Reliability & Robustness Metrics
- **DVP&R**
- **Reliability Demonstration Metrics**

DFSS (DCOV) Flow of Analysis & Tools



GENERAL DYNAMICS
Land Systems

Design For Reliability Map



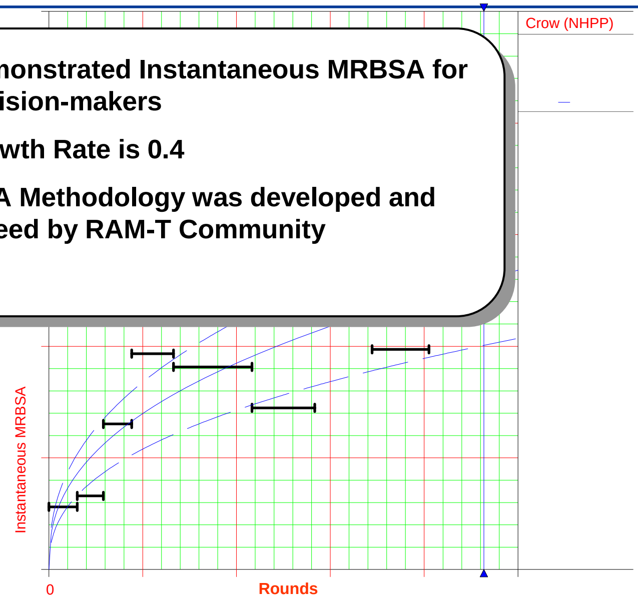
3. Define
Control
Factors

GENERAL DYNAMICS
Land Systems

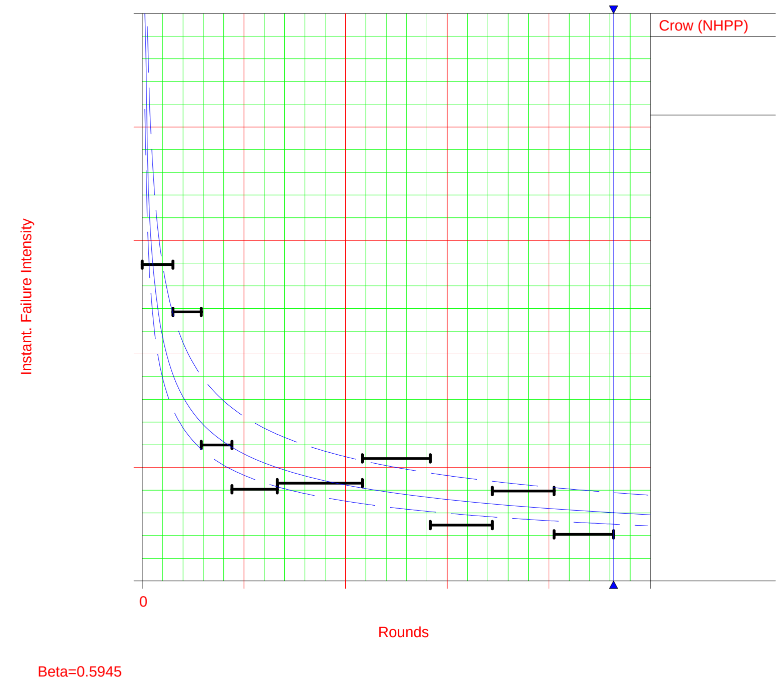
MIL-HDBK-189 RGA Method
MGS MEP PVT Instantaneous MRBSA

R

- **Demonstrated Instantaneous MRBSA for decision-makers**
- **Growth Rate is 0.4**
- **RGA Methodology was developed and agreed by RAM-T Community**



- **Failure Rate continues to decrease, thus demonstrating substantial reliability growth in PVT**
- **Sustained decrease of MGS Failure Rate suggests infant mortality region is passed and design is maturing**



<u>Continuing the effort to ensure MGS reliability growth</u>

- **Systems Engineering Process continues to be worked "24/7"**
- **GDLS Senior Leadership briefed on a daily basis**
- **Focus on implementation of Corrective actions on both the Test Vehicles and the Fielded vehicles**
- **GDLS teams at our vendors to work failure analysis and ensure MGS gets their top priority**
- **Outside experts on reliability and quality regularly review our processes in engineering and Manufacturing so we keep getting better**

Keys to Success

- Program Management forms Integrated Team (Material Developers, Tester/Evaluators, User) that has clear priority and focus on Reliability with clear understanding of Evaluation Criteria and Test Methods up front.
- System Engineering assembles Reliability tools into Disciplined processes and Working Organizations
- Reliability Assessment is reached through in-depth analysis and consensus between all involved parties

Program Management + System Engineering + Reliability = Success

Questions and Discussion

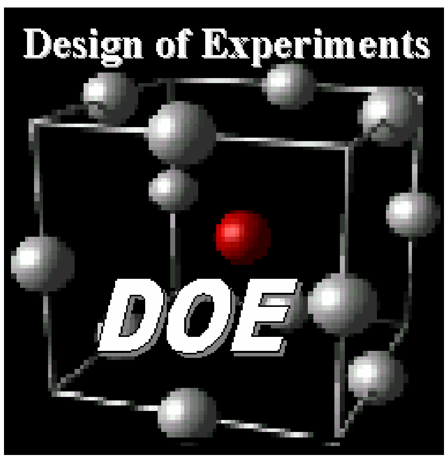
GENERAL DYNAMICS
Land Systems

GENERAL DYNAMICS

- Dmitry Tananko, Ph.D.
  - ➢ General Dynamics Land Systems
  - ➢ Tel.: (586) 634-5071
  - ➢ E-mail: tanankod@gdls.com

24th Annual NDIA Test and Evaluation Conference
25-28 February 2008, Palm Springs, CA

Applying Design of Experiments (DOE) methodology to Sortie Generation Rate (SGR) Evaluation



Josh Tribble
MILITARY ANALYST
AVW TECHNOLOGIES

Phone: 757-361-9587
E-mail: tribble@avwtech.com
860 Greenbrier Circle, Suite 305
Chesapeake, VA 23320
http://www.avwtech.com

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

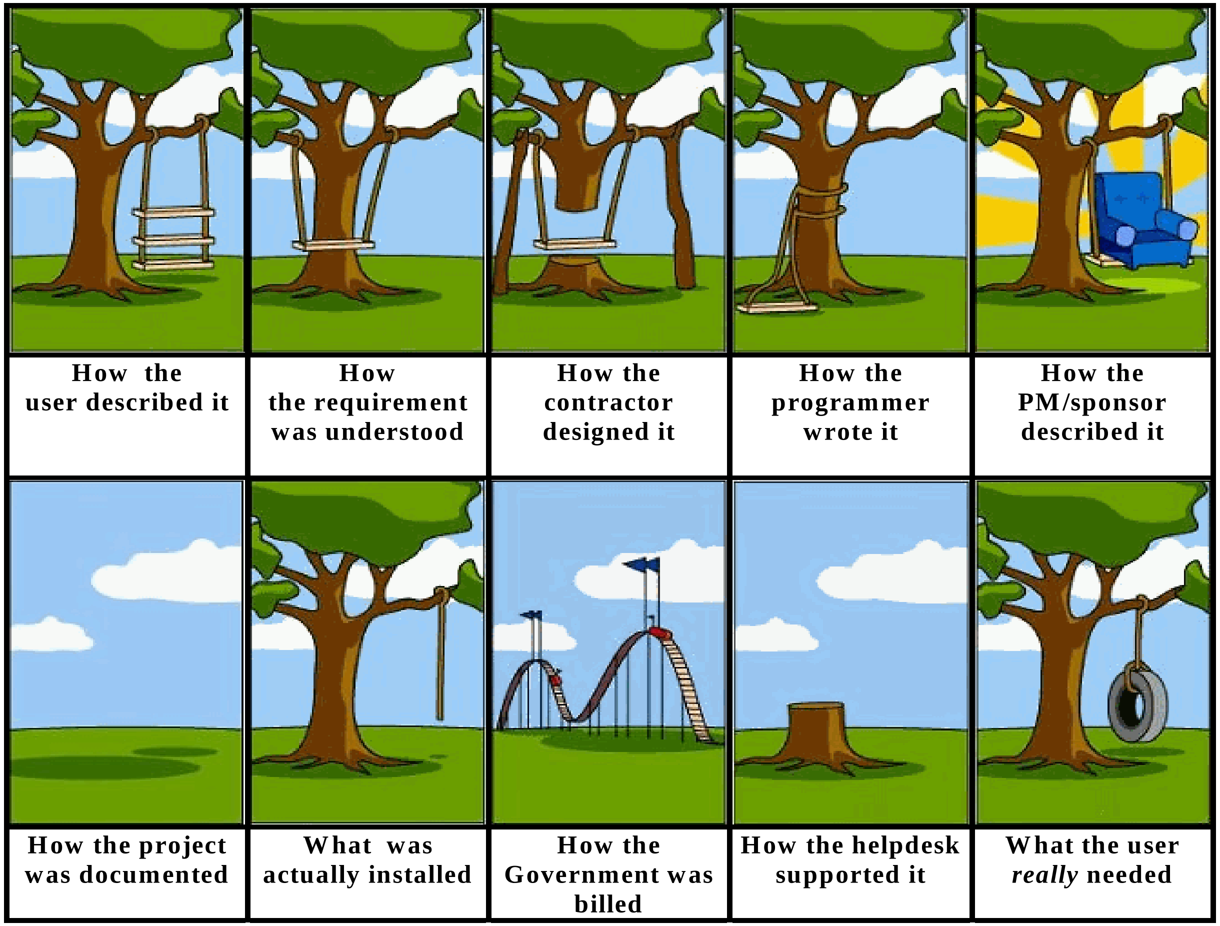
Agenda

- Introduction
  - Acquisition humor
  - The Integrated T&E Challenge
- Intro to Design of Experiments
- SGR Assessment Methodology
  - Overview of SGR Assessment to date
  - SGR Assessment objectives, MOEs, factors
  - SGR Testbed Assessment Design Factors / Run Matrix
  - SGR Live Testing Validation
- Benefits of DOE over single scenario based analysis
- Conclusion / Q&A

NOTE: My remarks are intended to spur thought on improving how we as testers can do business better to support the warfighter. While I hope this aligns well with DoD and Services T&E initiatives, I am not representing any government agencies' official position.

AVW TECHNOLOGIES

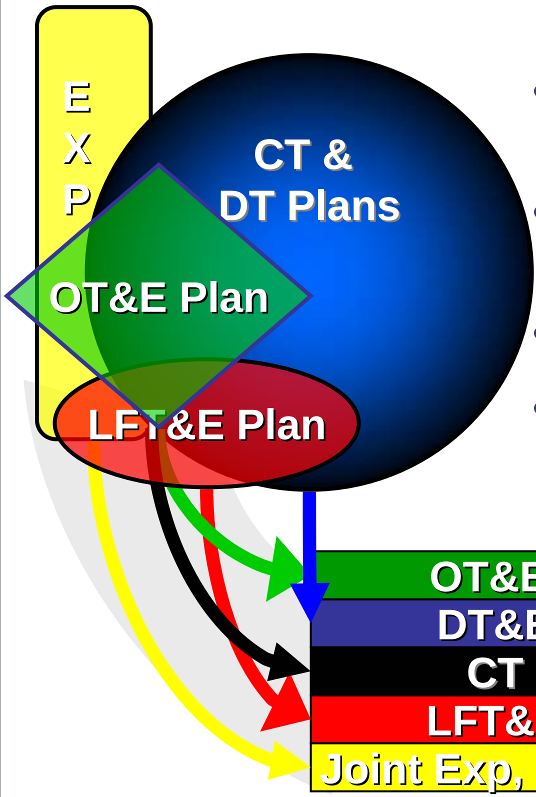
Acquisition 101?

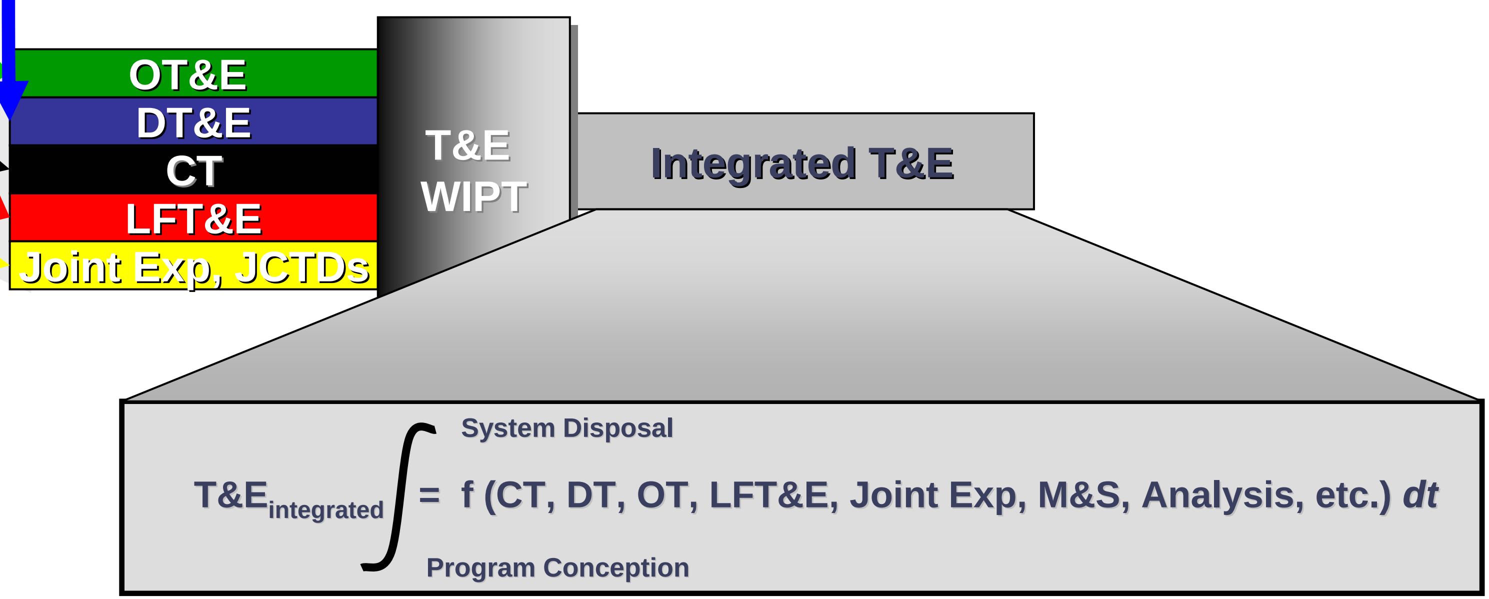


How do we avoid this?

Integrated T&E Challenge

- Coordinated planning and development of individual test objectives
- DT / CT / OT / LFT&E remain separate but leverage data and resources whenever possible
- Potential for significant cost savings and earlier risk reduction
- Requires buy-in from all orgs + strong T&E Working IPT
- Requires strong, up-front, test planning and data analysis methodology – ***Design of Experiments (DOE!)***





Intro to DOE

Background of DOE

- DOE originated in the field of agricultural studies in the 1930s by R. Fisher, building on W.T. Gossett's work at Guinness Brewery—Brilliant!
- Used throughout industry in industrial experiments, process improvement, statistical process control
- USAF has significant experience in use of DOE across numerous programs; Navy is beginning to implement
- DOE methodology is used to interrogate a process, improve knowledge of how the process works, and identify factors and interactions affecting variability of performance outcomes.

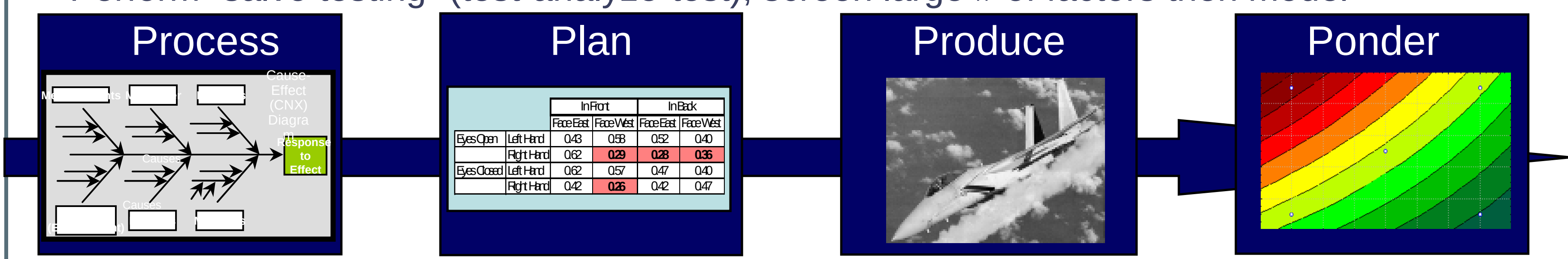
DOE Process Goal / Benefits

- Compared to other systematic methods DOE designs:

  - Yield better process understanding
  - Can be planned and analyzed faster
  - Cheaper – using between 20-80% of usual runs/tests/resources
  - Better exploration across range of performance—depth and breadth of testing
  - Challenge assumptions and demonstrate real performance
  - Better way to design and test complex systems

DOE Process Outline—4 Basic Steps

- **Project description and decomposition**
  - Problem statement and objective of experiment (test)
  - Response variables, and potential causal variables – Ishikawa fish bone.
- **Plan test matrix**
  - Determine constraints, prioritize factors, and select statistical design (2^K vs. 3^K vs. mixed, Taguchi vs. classical arrays, full vs. fractional, non-linear effects?, replications?, blocking?)
  - Write the test plan with sample matrices, profiles, and sample output; run sample analysis.
- **Produce observations** –random run order & blocked against unknown effects
  - Block runs to guard against uncontrollable unknown effects as needed.
- **Ponder the results**
  - Analyze and project data; draw conclusions, redesign test as necessary and assess results.
  - Perform "salvo testing" (test-analyze-test); screen large # of factors then model



		In Front		In Back	
		Face East	Face West	Face East	Face West
Eyes Open	Left Hand	0.43	0.58	0.52	0.40
	Right Hand	0.62	0.29	0.28	0.36
Eyes Closed	Left Hand	0.62	0.57	0.47	0.40
	Right Hand	0.42	0.26	0.42	0.47

SGR Assessment Methodology

SGR Assessment Requirements

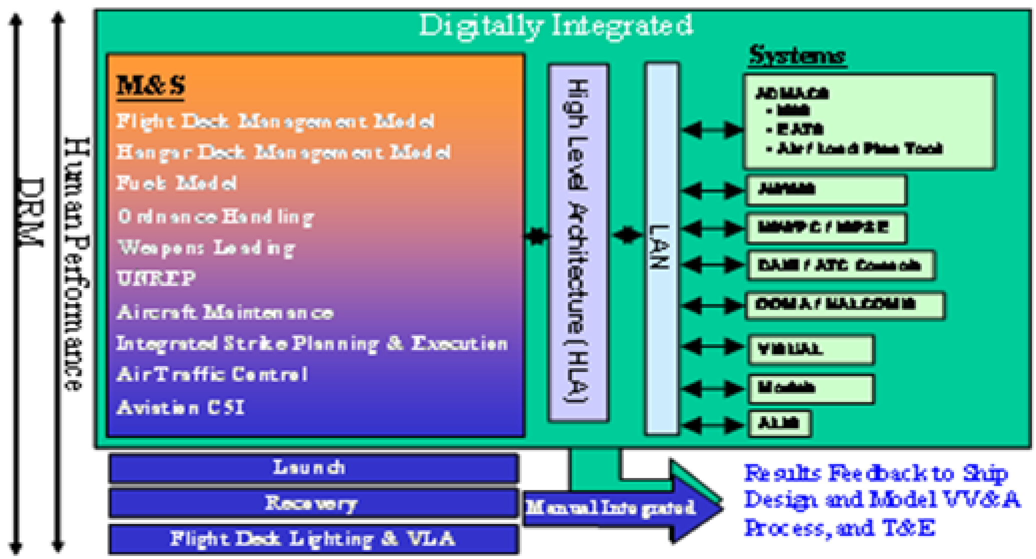
- **SGR Key Performance Parameter**

	THRESHOLD	OBJECTIVE
Sustained SGR	Average of 160 operational combat equivalent aircraft sorties in 12 hours of launching per day over 30 days (26 Flying and 4 Non-Flying Days as specified in the Design Reference Mission (DRM) – total cycle of 4160.	Average of 220 operational combat equivalent aircraft sorties with 12 hours of launching per day sustained over 30 days (26 Flying and 4 Non-Flying Days as specified in the DRM) – total cycle of 5720.
Surge SGR (requires crew augment)	Average of 270 operational combat equivalent aircraft sorties generated during each successive 24-hour period over 4 continuous days.	Surge: average of 310 operational combat equivalent aircraft sorties generated during each successive 24-hour period over 4 continuous days.

- **Other Measures of Performance:** cycle times, task timing, launch and recovery cycles, resource usage, crew fatigue levels, fuel states/rates, etc.

SGR Assessment Testbed

- M&S testbed captures times and actions associated with preparing, launching, and recovering sorties per the DRM



- M&S matured and validated over time prior to runs for score
- Live test used for validation once ship is delivered and aviation certified

AVW TECHNOLOGIES

SGR Model

SGR is a function of

- Launch Cycle/Interval Timing
- Recovery Times/Intervals
- Mission Planning Timing
- Aircraft Recovery Time Which Encompasses:
  - Fueling Time
  - Ordnance Handling Times
  - Aircraft Movement/Spotting Times On The Flight Deck
  - Aircraft Movement/Spotting Times In The Hangar Bay
  - Aircraft Availability

SGR Assessment Analysis Objectives

- Determine average SGR over DRM to meet KPP requirement
- Determine active factors influencing the variability & overall outcome
  - Measure % sorties completion rather than binomial pass/fail
  - Each day in the DRM treated as a single design point due to interdependencies of events within that day
- Provide the fleet with an analytical model showing probability of meeting a given airplan based on its size, mission composition, environment, and any other active factors

$$\%Airplan\_Sorties\_Completed = \frac{Daily\_sorties\_completed\_succesfully}{Airplan\_sorties} x100\%$$

  - Allows equal comparison of the 4 T/O surge/sustained requirements across all factors
  - Continuous dependent variable provides more statistical power than pass/fail
  - Supports more robust assessment of capes and lims

SGR Factor Selection

Experimental control factors:

- Environmental
  - Sea/Winds: state 1 vs. 3
  - Visibility/Sky Cover: Clear Skies (Case I) or Cloudy/Night (Case III)
  - Time of day: midday or midnight (for 12 hour ops, N/A for 24 hour ops)
- Systems:
  - Availability: 100% & actual (for CVN-21 systems and aircraft)—allows for analysis of impact of equipment failures
- Mission
  - Sortie Size: Threshold & Objective levels from the DRM
  - Sustained and Surge Mission (12 vs. 24 hr ops (with augmented crew))
  - Operation day: early and late in ship on-station operational period; expect to interact with availability for system failures and also translates to possible crew fatigue
  - Airplan mission mix: early/late DRM days representing different ordnance mix;
  - Mission mix and operation day

SGR Factor Selection (cont')

Controllable Factors held constant:

- Underway Replenishment
  - Not a factor of SGR but presumed to occur on assigned days or fuel and ordnance will not be available for the planned flight days)
- Aircrew augmentation
  - Confounded with mission type – assumed normal crew for sustained operations and augmented crew for surge missions

Measurable Noise Factors

- Other environmental factors not controlled (if in test / model)
  - Temperature extremes
- Specific metrics in the subordinate models driven by the main inputs, such as:
  - Crew fatigue (driven by the mission day)
  - Resource availability
  - Number of aircraft available
  - Weapon skids available
  - Timing for critical tasks, etc.

SGR Factor Selection (cont')

- Design factors:
  - Factors with highest expected influence listed first
    - Important when setting up fractional factorial matrices—usually easier to resolve factors and interactions
  - Setup for M&S only; cannot test all of these in live testing
  - Requires M&S improvements
  - Need buy-in for "excursions" above threshold
    - High levels force the "system" towards a higher failure rate to see more variation in response

Setting Factor		**(Low) -1**	**(Center Point) 0**	**(High) +1**
A	Surge/ Sustained Operations	Sustained (12 Hr ops)	N/A	Surge (24 Hr ops w/augment)
B	Sortie Size (T/O)	Thres-hold	Halfway btwn	Objective
C	operational day	Early (1/4 or 5/30)	Mid (2/4 or 15/30)	Late (4/4 or 26/30)
D	Availability	100%	Halfway btwn	actual/ spec
E	Visibility/ Cloud Cover:	Clear/ Case I	Partly Cloudy/ Case II?	Cloudy/ Case III
F	Seakeeping motion effects	5 kts/SS1	12 kts/SS2	20 kts/SS 3
G	Time of day	Day	Dusk?	Night
H	Mission Day	Early	Mid	late

SGR Testbed Run Assessment Design

- Full factorial requires 2^8 or 256 runs
  - *Unnecessary since many effects are inactive*
- Resulting test matrix is a resolution IV 2^{8-4} fractional factorial of 16 runs + 8 additional runs for central composite design
  - *Some interactions are confounded but can be resolved*
- Model DRM days per the assigned settings and evaluate SGR Compl %
- “salvo test”:
  - Runs 1-8, then analyze for effects
  - Runs 9-16, then reanalyze for effects
  - Perform center points to check for linearity
  - If necessary, run CCD (face points) for non-linear effects

Run		Blk	A	B	C	D	E = ABD	F= ACD	G= BCD	H= ABC
1	Factorial	1	-1	-1	-1	-1	-1	-1	-1	-1
2	Factorial	1	-1	-1	-1	+1	+1	+1	+1	-1
3	Factorial	1	-1	-1	+1	-1	-1	+1	+1	+1
4	Factorial	1	-1	-1	+1	+1	+1	-1	-1	+1
5	Factorial	1	-1	+1	-1	-1	+1	-1	+1	+1
6	Factorial	1	-1	+1	-1	+1	-1	+1	-1	+1
7	Factorial	1	-1	+1	+1	-1	+1	+1	-1	-1
8	Factorial	1	-1	+1	+1	+1	-1	-1	+1	-1
9	Factorial	2	+1	-1	-1	-1	+1	+1	-1	+1
10	Factorial	2	+1	-1	-1	+1	-1	-1	+1	+1
11	Factorial	2	+1	-1	+1	-1	+1	-1	+1	-1
12	Factorial	2	+1	-1	+1	+1	-1	+1	-1	-1
13	Factorial	2	+1	+1	-1	-1	-1	+1	+1	-1
14	Factorial	2	+1	+1	-1	+1	+1	-1	-1	-1
15	Factorial	2	+1	+1	+1	-1	-1	-1	-1	+1
16	Factorial	2	+1	+1	+1	+1	+1	+1	+1	+1
17	Center rep 1	3	-1	0	0	0	0	0	0	0
18	Center rep 2	3	-1	0	0	0	0	0	0	0
19	cd face point –b	4	-1	-1	0	0	0	0	0	0
20	cd face point +b	4	-1	+1	0	0	0	0	0	0
21	bd face point –c	4	-1	0	-1	0	0	0	0	0
22	bd face point +c	4	-1	0	+1	0	0	0	0	0
23	bc face point –d	4	-1	0	0	-1	0	0	0	0
24	bc face point +d	4	-1	0	0	+1	0	0	0	0

SGR Live Testing Validation Test Design

- Live test conditions and cost (potentially $100M?) limit amount of live test and the conditions
- Focus on validating specific test points of interest and confirm within the M&S runs for score

Factor		-1	0	+1	Rationale
A	Surge/ Sust. Ops	**Sustained**	N/A	**Surge**	Both operations can be run
B	Sortie Size (T/O)	**Threshold**	**(T+ O)/ 2**	**Objective**	A mix of sortie sizes can be run
C	Operational day	**Early**	Mid	Late	No means of imposing a late day due to cost
D	CVN-21/A/C Ao	100%	Halfway	**Actual**	Actual equipment Ao
E	Cloud Cover	**Actual conditions?**			
F	Sea-State	**Actual conditions?**			
G	Time of day	**Actual conditions?**			
H	DRM Mission mix	**Early**	**Mid**	**Late**	Factor is probably inactive so randomly assign

SGR Live Testing Validation Test Design (cont')

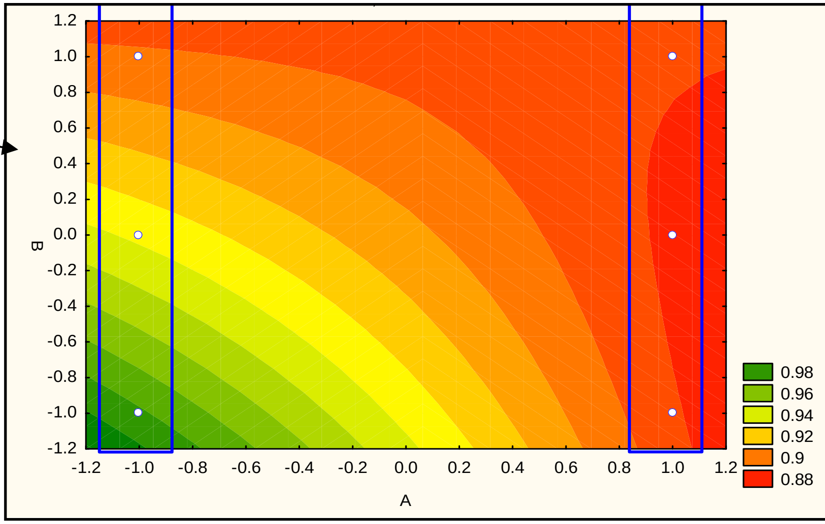
- Final Test Matrix with settings:

Test Case	**A: Ops Type**	**B: Sortie Level**	*Actual (# Sorties)*	**H: DRM Mission Day**	**Notes**
1	Sustained	Threshold	*160*	5	**Priority**
2	Sustained	Objective	*220*	26	**Priority**
3	Surge	Threshold	*270*	26	**Priority**
4	Surge	Objective	*310*	5	**Priority**
5	Sustained	Halfway btwn	*190*	15	Additional run for midpoint
6	Surge	Halfway btwn	*290*	15	Additional run for midpoint
7	Sustained	Threshold	*160*	26	Additional run for alternate mission mix
8	Sustained	Objective	*220*	5	Additional run for alternate mission mix

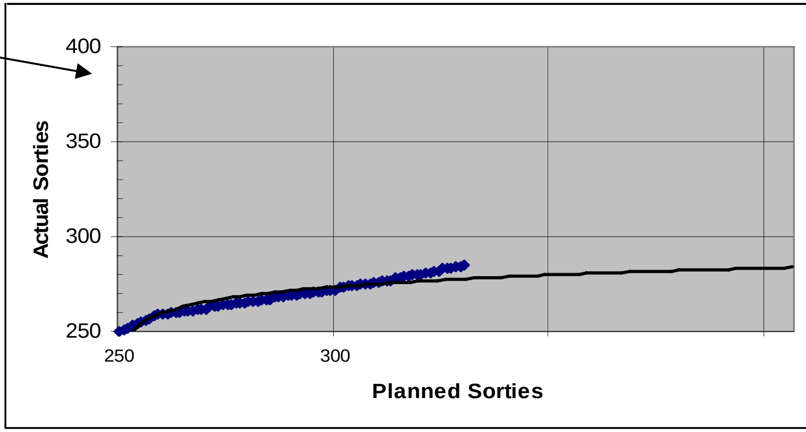
- Recommend run during Joint Task Force Exercise to ensure combat ready crew & systems
- Some analysis of variance can be run directly but main objective is to compare day for day with M&S results (including V&V of lower level measures within the specific process models)
- Runs 1-4 are priority; select additional runs based on M&S results

SGR Testbed Assessment
Sample Data Analysis

- Response surface plot across factors of interest showing response & interactions



- Table of plan vs. predicted actual SGR Completion Rate for factor settings of interest -- shows SGR completion % falling off as too many are sequenced



- ***demonstrates how analysis can describe ship caps & lims, not just a pass/fail grade for a KPP tested only to threshold***

Benefits of DOE

CONCLUSION

- **DOE methodology:**
  - –*may significantly* ***reduce the required runs*** *for Testbed Assessment and live test validation while...*
  - –*providing a* ***more robust process*** *for statistical analysis of variance to determine where the ship design can and cannot support a given air-plan under the other conditions*
  - –*supports robust & efficient* ***integration of M&S development, testing, VV&A, & evaluation***

- **DOE is:**
  - ***–a smarter way of doing testing***
  - ***–can provides superior knowledge to the systems engineers***
  - ***–something all testers & systems engineers should become familiar with!***
- **QUESTIONS?**

Systems Evaluation of Unmanned Aircraft Systems

Juan Vitali
(703) 681-1677

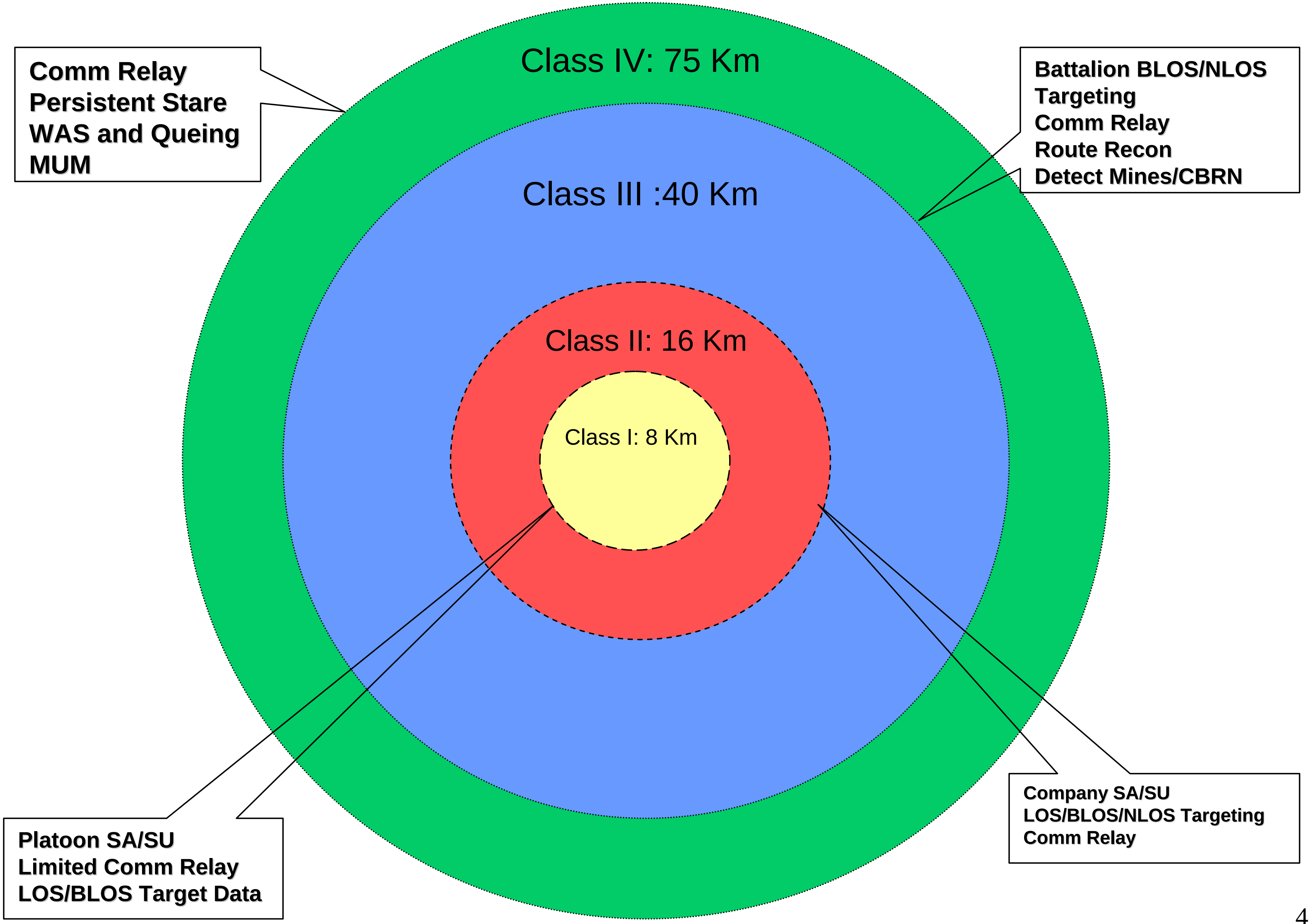
Agenda

- Overview of Current UAS missions
- Case study: Small UAS Evaluation
  - OPEVAL
  - OT
  - Lessons Learned
  - Doctrine Changes

URGENT! UASs are needed in the Battle Field Missions

- Need in OEF/OIF to perform Recon Surveil. Target Acq. Missions at platoon level: RAVEN, DRAGON FLY
  - Look for insurgent activity and provide target info to fire support
  - Use in PSY OPS
- Retrofit with BAT munitions and use to deliver lethal and accurate force: HUNTER VIPER STRIKE
- Use as persistent stare asset, for wide area surveillance at high altitudes and target acquisition, company level –WARRIOR A, GLOBAL HAWK, REAPER
- Use as signal relay platforms for connecting to GIG –ERMP, SHADOW, ER/MP, FCS Class IV (FIRE SCOUT)
- Man Un Manned (MUM) Teaming to use as a forward asset to provide target information to AH-64 – ERMP, HUNTER
- EOD and surveillance: use ahead of convoys for looking at road details up close, platoon level – g-MAV, FCS CLASS I UAS

ARMY UAS PROGRAMS



Overall Evaluation Approach:
Start with …how is the USER employing the UAS?

- Concept of Operations
- Operation and Organization
- Operational Mode Summary/Mission Profile
- Capability Development Document (Requirements)
- Critical Operational Issues (and Criteria)
- Development of MOEs/MOPs/MOSs
- Design of OT to include END TO END mission accomplishment

Case Study: RAVEN UMR and Small UAS POR In Support of Combat Missions

Purpose

- Discuss Means to Assess Capabilities and Limitations on Raven UAS Shipped for Rapid Deployment to Operations Enduring Freedom/Iraqi Freedom (OEF/OIF)
- Assess Enhancements in Close Combat Missions Using Small Unmanned Aircraft Systems (SUAS)

Data Sources

- RAVEN: Responses from Commanders and Raven operators in OEF/OIF
- SUAS: Production Qualification Testing, Airborne Testing and Initial Operational Testing

SUAS Test and Evaluation

- Evaluate SUAS Effectiveness, Suitability and Survivability
- Analyze Changes in Army Doctrine Relevant to Using the SUAS

Raven UAS Description

Small all-electric UAS

- **Endurance ~ 60 minutes (90 minutes total)**
- **Range (radio line of sight) ~ 10 Km**
- **Airspeed ~ 40 knots cruise – 52 knots maximum**
- **Provides real-time daylight color video or IR and coordinate information and position of AV**
- **Fully autonomous waypoint navigation, automatic altitude and heading reporting**

Raven Capabilities/Limitations

Enhances Situational Awareness

- Reconnaissance
  - Convoy escort – Recognize vehicles, or detect personnel activity next to a road
  - Point and route reconnaissance, cover sectors of urban areas while patrols go house to house
- Surveillance
  - Cordon and search operations – loiter over building(s) of interest
  - Perimeter defense – detect and get closer look at vehicles
- Target Acquisition
  - Use Raven coordinates to narrow target location and ID

Raven Capabilities/Limitations

- **Operators Report Raven is Simple to Assemble, Program, Launch and Recover**
  - AV parts press in place without tools – ready in 5 minutes
  - Navigation Waypoints Programmed using MGRS
  - No Need for a Runway – Small Operations/Logistics Footprint
  - Damage to the Air Vehicle Occurs Mainly During Launch and Recovery
- **Challenges in Airspace Coordination and Frequency De-confliction**
  - Extensive Planning and Mission Requests on Par with Manned Aircraft Missions
- **Susceptibility to Visual and Audible Detection**
  - Ravens are Difficult to See and Avoid Due to Small Size – Mix with Manned Aircraft
  - Less Noise than larger UASs

SUAS System Description

System Description

- Modified Raven - Improved Visible Daylight Side View Camera and IR + Laser Pointer
- Ground Control Station and Remote Video Terminal are Interchangeable
- Raven Air Vehicle Remains Unchanged
- Center Field of View Coordinates to Target

Hand-held Video/Controller

Air Vehicle (three each)

Ground Control Station

Remote Video Terminal

SUAS Test and Evaluation

- **SUAS is the Army Acquisition Program of record and Fielding of the Upgraded Raven**
- **Test and Evaluation Strategy**
  - **Effectiveness**
    - Answer Critical Operational Issue (COI) *“Does the SUAS Enhance the Combat Effectiveness of a Small Unit?”*
    - Leads to Comparative Analysis of Close Combat Missions with and Without the SUAS
    - Force on Force Test Examines Use of the SUAS During Attacks, Raids, Convoy Escort, and Observation of Known Areas of Interest
    - Evaluates Technical Requirements the System Must Meet (Range to Target, Interoperability, and Capability to Detect/Recognize Vehicles and Personnel)
    - Data Obtained from Initial Operational Test (IOT)

SUAS Test and Evaluation

- **Test and Evaluation Strategy (Continued)**
  - **Suitability/Survivability**
    - Answers Critical Operational Issue *“Does the SUAS Support the Small Unit’s Sustained Operational Requirements?”*
    - Required Reliability Testing, Portability, Transportability, Airborne Capability MANPRINT, and Supportability Assessments
    - System Reliability Data Obtained From Production Qualification Testing, and IOT
    - Portability Assessed through dismounted operations During IOT
    - During the Logistics/MANPRINT Demonstration Verified/Validated Technical Manuals, Training, Assembly/Disassembly, Preventive Maintenance Checks and Services (PMCS), MOPP IV and Cold Weather Tasks
    - Electromagnetic Environmental Effects (E3) Data Collected from Production Qualification Testing
    - System Susceptibility to Acoustic Signature obtained from Developmental Test and IOT

Approach to Evaluating Effectiveness

- **Initial Operational Test (IOT)**
  - Mission Matrix Consists of 21 Infantry Company Level Close Combat missions
  - Nine Pairs of Comparison Missions with and without the SUAS
  - Three to Meet Data Requirements According to the OMS/MP and for the Purpose of RAM

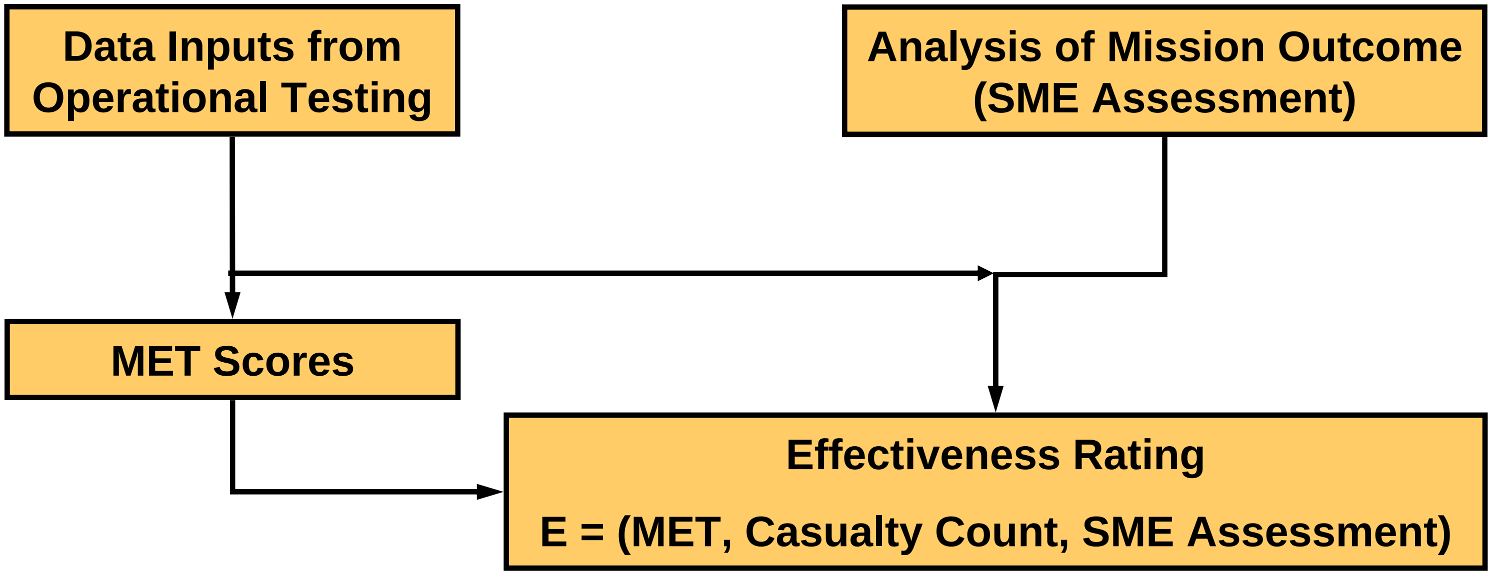
MISSION	Daytime		Nighttime	
	With SUAS	Without SUAS	With SUAS	Without SUAS
Conduct a Convoy Escort (ARTEP 71-2-2320)	1	1	1	1
Conduct an Attack by Fire (ARTEP 71-2-0219)	1 and (1)	1	1	1
Conduct a Raid (ARTEP 71-2-0308)	1 and (1)	1	2 and (1)	2
Defend a Battle Position (ARTEP 71-2 2603)	1	1	1	1

Approach to Evaluating Effectiveness

- **Comparative Test With and Without the SUAS Required Using a Robust OPFOR and Cluttered Environment to Challenge the Test Unit**
- **Mission Effectiveness Templates (MET) and Assessment of Mission Outcome by Subject Matter Experts**
  - METs use Timeliness, Accuracy, and Unit Resources as Attributes to Objectively Score Missions With and Without the SUAS
  - ARTEP MTPs Assessed by O/Cs to Observe Accomplishment of Task Steps
  - The Entire Mission is Timed by Distinct tasks, SALUTE Reports are Recorded and Actions the Unit Takes to Complete the Mission
  - SMEs Individually Assess the Mission as it Unfolds in the Battlefield and Based on Mission Outcome Determine Mission Success and Commander’s Intent

ARTEP=**A**rmy **T**raining And **E**valuation **P**rogram
SALUTE=**S**ize **A**ctivity **L**ocation **U**nit **T**ime **E**quipment
MTP=Mission **T**raining **P**lan

Approach to Evaluating Effectiveness



CC = Casualty count factor; CC = R – 2(B + NC)
R: % OPFOR killed or captured
B: % BLUFOR killed or captured
NC: % NON COMB. killed or captured

Approach to Evaluating Effectiveness (Mission Effectiveness Templates)

Timeliness (30%) (T) Score	100	0	Actual	
Planning (40%)				
Mission Planning Time (20%)	30	240	_____	X 0.024 =
Time to Initial SALUTE Report (80%)	20	240	_____	X 0.096 =
Execution (60%)				
Mission Execution Time (LD) (100%)	30	240	_____	X 0.180 =
Accuracy (50%) (A)				
Battalion PIRs (30%)				
Number of PIRs Detected* (50%)	Detections	0	_____	X 0.100 =
Number of PIRs Recognized (50%)	Recognitions	0	_____	X 0.100 =
Planning (40%)				
Man-sized Object Detections (50%)	Detections	0	_____	X 0.100 =
Locations (20%)	Recognitions	0	_____	X 0.040 =
Vehicle Recognitions (30%)	Recognitions	0	_____	X 0.060 =
Execution (30%)				
Man-sized Object Detections (50%)	Detections	0	_____	X 0.100 =
Locations (20%)	Recognitions	0	_____	X 0.040 =
Vehicle Recognitions (30%)	Recognitions	0	_____	X 0.060 =

PIR= Priority **I**nformation **R**equirements

Approach to Evaluating Effectiveness (Mission Effectiveness Templates)

Company Resources (20%) (R)	Score 100	0			Actual
Planning (40%)					
Personnel (50%)	2	15	______	X 0.040	=
Vehicles (50%)	0	2	______	X 0.040	=
Execution (60%)					
Personnel (50%)	2	15	______	X 0.060	=
Vehicles (50%)	0	2	______	X 0.060	=

MET Score = T + A + R

- Total Scores Without SUAS Compared to Total Scores With SUAS Using a t-distribution Paired Samples Test and Wilcoxon Signed Rank Test

Approach to Evaluating Effectiveness

Results of Mission Effectiveness Template Scores by Mission			
		With SUAS	Without SUAS
Attack	Day	34.9	34.1
	Night	35.4	19.8
Raid	Day	43.0 (0 score)	24.2
		47.9	41.9
	Night	23.4 (0 score)	36.3
Convoy Escort	Day	40.5	46.7 (0 score)
	Night	41.5	42.4 (0 score)
Defense (Observe NAI)	Night	38.4	20.2

Note: Scores highlighted in red have a zero rating due to an unsuccessful mission outcome

Statistical Analysis Using a Paired Samples Test and Wilcoxon Signed Ranks Test			
Paired Samples Test		**Wilcoxon Sign-Rank Test**	
t-Ratio	0.777403		
Degrees of Freedom	7	Test Statistic	5
Prob *p* > |t|	0.4624	Prob *p* > |z|	0.547
Prob *p* > t	0.2312	Prob *p* > z	0.273

Loss Exchange Ratios

Mission Type		Losses With SUAS				Losses Without SUAS			
	Day/Night	OPFOR	BLUFOR	Non-Combatants	Score	OPFOR	BLUFOR	Non-Combatants	Score
Convoy operations	Day	0%	0.0%	0.0%	55.8	88.9%	0.0%	0.0%	100.0
Convoy operations	Night	0%	0.0%	0.0%	55.8	50.0%	9.1%	0.0%	71.6
Hasty Attack	Day	35.3%	0.0%	0.0%	73.3	40.0%	9.7%	10.5%	55.5
Hasty Attack	Night	81.8%	4.1%	36.8%	55.8	0	0.0%	0.0%	55.8
Raid to capture	Day	80.0%	0.0%	15.4%	80.3	75.0%	10.5%	0.0%	82.6
Raid to capture	Day	85.7%	35.7%	0.0%	62.9	70.0%	11.1%	11.8%	67.8
Raid to capture	Night	30.8%	0.0%	0.0%	71.1	55.6%	2.6%	81.3%	0.0

Table 6. Loss exchange ratios on missions with and without the SUAS

Critical T-value= 1.943, thus no statistical significance

Approach to Evaluating Effectiveness

- **Evaluation of SUAS Effectiveness**
  - SUAS Demonstrated Negligible Enhancements in Combat Effectiveness at the Company Level
  - SUAS Enhanced Situational Awareness Based on Closed Set of Close Combat Mission Iterations – used to confirm course of action
  - MET Scores Show No Significant Differences in Mission Outcome
  - System Interoperability Proven in 95% (25 of 26) Successful Downloads from the GCS to the Laptop
  - SUAS Demonstrated Insufficient Capability to be used in Call for Fire Tasks
  - AV Flown Mostly at Lower Altitudes to Recognize Personnel

Approach to Evaluating Suitability/ Survivability

- **Reliability Availability and Maintainability**
  - Did Not Meet MTBOMF for sub-systems: The AV is a risk item with much lower MTBOMF than anticipated
    - Battery issues caused crashes
    - Bent motor shafts from failed launches
- **Portability**
  - Demonstrated Rucksack Portability Weight < 25 lbs to Include Single Air Vehicle
- **Capability For Airborne Operations –** Static Line and HALO Jumps Met
- **Launch and Recovery without the Need for a Runway**
  - Twenty one of 61 Launches Resulted in Failure – Attributed to Nighttime Slight Wind Conditions
  - Emphasize Operator Training on Launch Techniques –
- **Navigation, Operation and Recovery Operations – Mounted/ Dismounted**
- **Flight Endurance –** Did not Show it could Meet the 90-minute Endurance Requirement During the IOT

Approach to Evaluating Suitability/ Survivability

- **Commander/Operator Workload**
  - Emphasize Commander Participation During Collective Training - Delegate Use of the System to the XO, or FSO to Focus on Key Missions Tasks
- **System Susceptibility to Loss of Link** – demonstrated in 10 of 28 Missions
- **AV is audible at Mission Altitude** – Opposing Force (OPFOR) changed mode of operation

Changes in Army Doctrine by Integrating the SUAS

- **Doctrine – ways to a means**
  - New weapon systems can instill revisions in Army doctrine – ways to conduct combat by reducing the size of the force
- **SUAS Tradeoffs to Reduce Size of Offensive Force**
  - Traditional Offensive Operations Count on a Three to One Offensive Force
  - Cannot Violate Principles of War – mass, surprise, economy of force, maneuver
  - SUAS must demonstrate capability as a force multiplier to enhance small unit effectiveness
  - Improve sensor technology to identify individuals and the location of Improvised Explosive Devices (IED)
  - Enhance interoperability to network with other UASs and UGVs – increase sensor coverage over target
- **SUAS is a good test case for Future Combat use of small UAVs**
  - Defines the technical envelope to look forward and meet small unit Aerial RSTA needs

Conclusions

- **Raven –** Operational history shows adequate RSTA task capability in limited Close Combat Missions at the Infantry Company Level
- **SUAS incorporates minor upgrades to Raven UAS**
  - Targeting Feature is a step in the right direction – not capable now
  - Requires stable platform and sensor
- **Benefits to the Small Unit**
  - Light Infantry Unit may make better use of the SUAS than say a mechanized Infantry Unit – lack of high power sensors limit capabilities in open terrain
- **Emphasize the Need for Powerful Sensors**
  - System risk to detection offers the opposing forces advantages to change modes of operation

Operational Test and Evaluation Force

National Test and Evaluation UV Conference Brief

RDML Stephen S. Voetsch

February 2008

UNCLASSIFIED

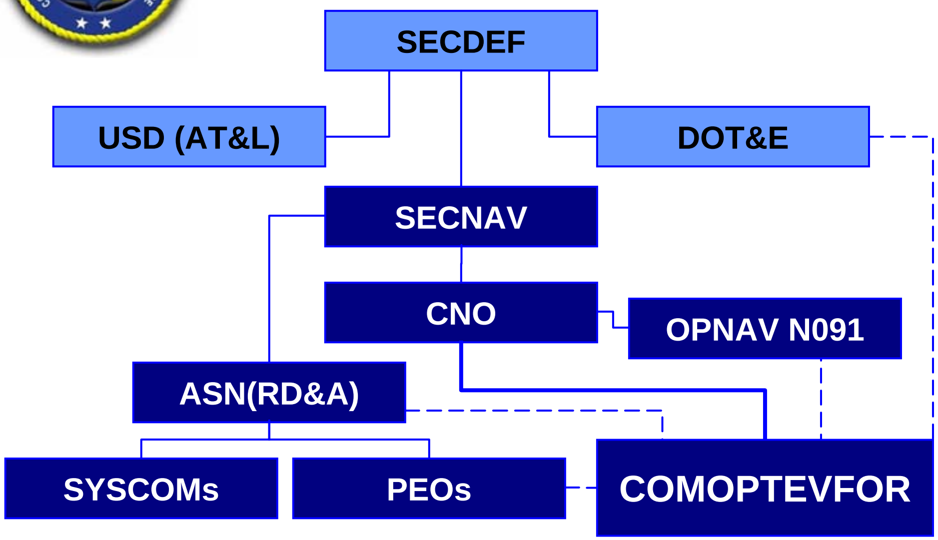
COMOPTEVFOR

Who we are

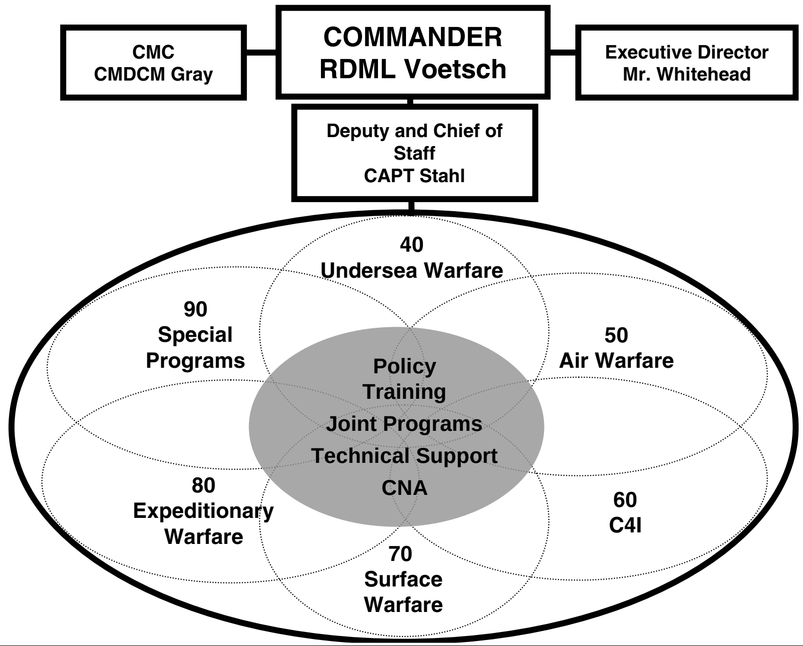
- Overview
- Mission Based Test Design
- Integrated Test
- Open Architecture

- Unmanned Vehicles
  - History – Present – Future
- OPTEVFOR Role in Capabilities & Requirements
- Discussion

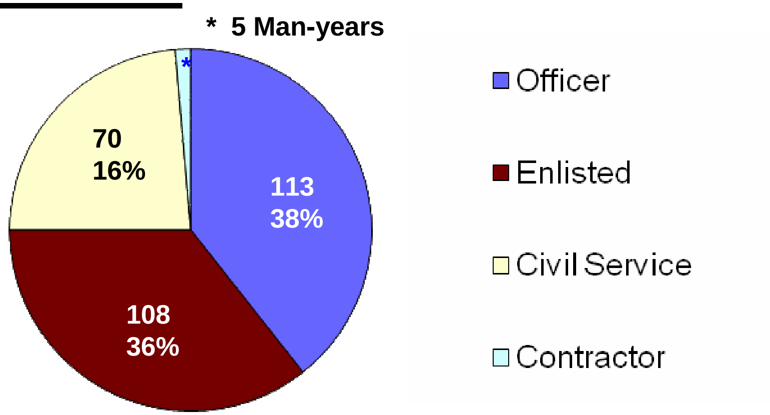
Portfolio



Note: Dotted line = coordination

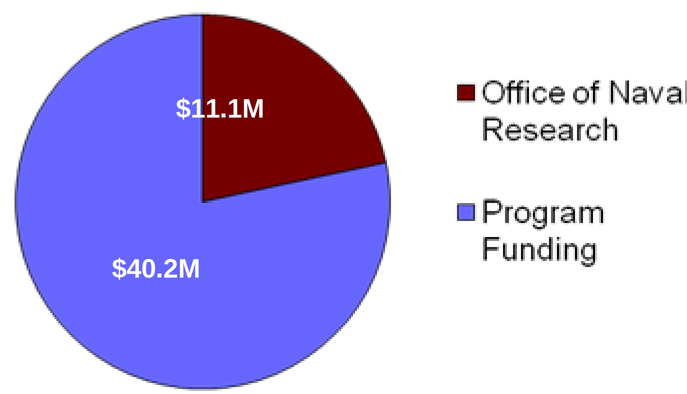


Workforce



COTF Headquarters Total: 296
(Does not include approx 135 Program Funded Contractors)

Budget



FY07: $51.3M

As of 01DEC2007

Portfolio

Undersea Warfare
ARC-I
VA Class ESM System
MK48 ADCAP
SSGN Class
VA Class
ISIS
Photonics Mast

Surface Warfare
Aegis Ballistic Missile Defense
USCG Multi-Mission Coastal Helo
SSDS
CEC
Evolved Sea Sparrow
CIWS Block 1B
DDG 1000
LPD-17
Rolling Airframe Missile
Tomahawk
DDG 51
LCS
SPY-1D
T-AKE
LHA-6

Air Warfare
EA-18G Growler
FA-18 ATFLIR
AESA
FA-18E/F H4E
AH-1W Helo Night Targeting System
AIM-9X
Improved Extended Echo Ranging System
IDECM
JMPS
JSOW-C
V-22
VH-71
H-1 Upgrade
JSF
SLAM ER
JDAM
USQ-113
EA-6B
CVN-21
JPATS
AARGM

C4I
ERP
Tactical/Mobile
NGEN
Maritime Domain Awareness
SEWIP
GCCS-M
Wideband Global SATCOM
CSEL
JICO support System
Net Centric Enterprise Services

Expeditionary Warfare
JBPDS
JCAD
JEOD
JSAM
SRDRS
Sea Eagle ACTD
JWARN
Joint Effects Model

Program list not all inclusive

Navy Initiatives

- **The Navy's Provider Enterprise**
  - **(T&E Board of Directors)**
- **T&E Cycle Time Reduction**
- **Mission Based Test Design**
- **Integrated Testing**

Single Process Owner

"The need for a T&E capability that is synchronized with product procurement across the spectrum is critical to support the Navy's future war fighting needs. As part of the enterprise integration of T&E there is a need for a single Navy T&E process owner. An additional dimension is the need for a more effective and efficient business model in the relationship between government and industry, the desire to achieve synergism, and produce a "win-win" situation for both entities."

COMOPTEVFOR "Streamline T&E" Report to CNO July 2005

T&E Board of Directors

CHIEF OF NAVAL OPERATIONS
ADM ROUGHHEAD

VICE CHIEF OF NAVAL OPERATIONS
ADM WALSH

ASN(RDA)
HONORABLE Mr Thackrah (acting)

COMOPTEVFOR
RDML VOETSCH

OPNAV N091
DoN T&E EXEC
ONR
RADM LANDAY

PEO
FORUM

Co-Chair

Co-Chair

T&E
Board of Directors

RADM Landay N091
RDML Voetsch COMOPTEVFOR
RADM Moffitt N43
VADM Sullivan NAVSEA
VADM Venlet NAVAIR
RDML Bauchmann SPAWAR
Ms Margret Harrell SES FFC
Program Executive Office

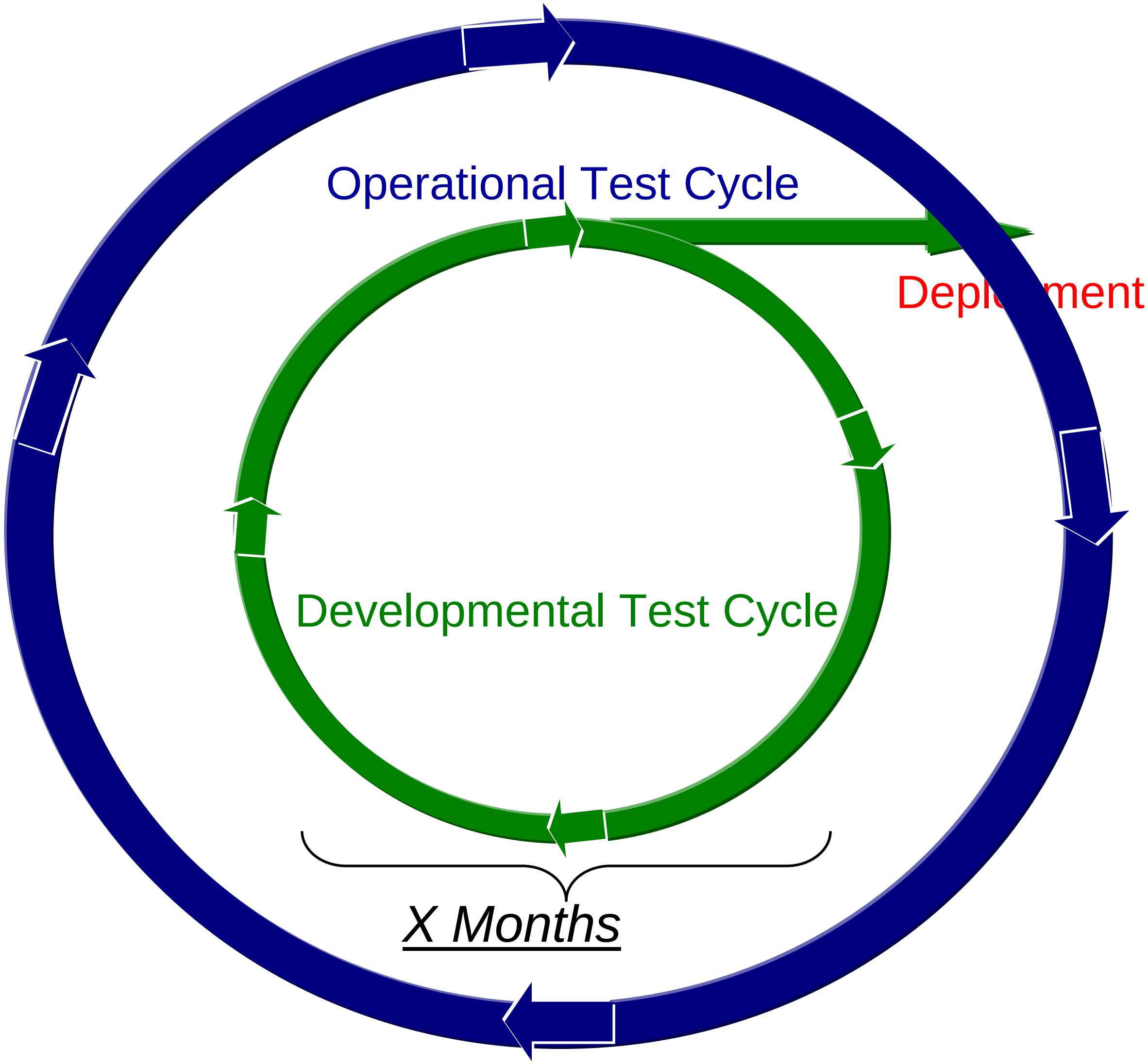
Mission Based Test Design

UJTL, CONOPS, METL

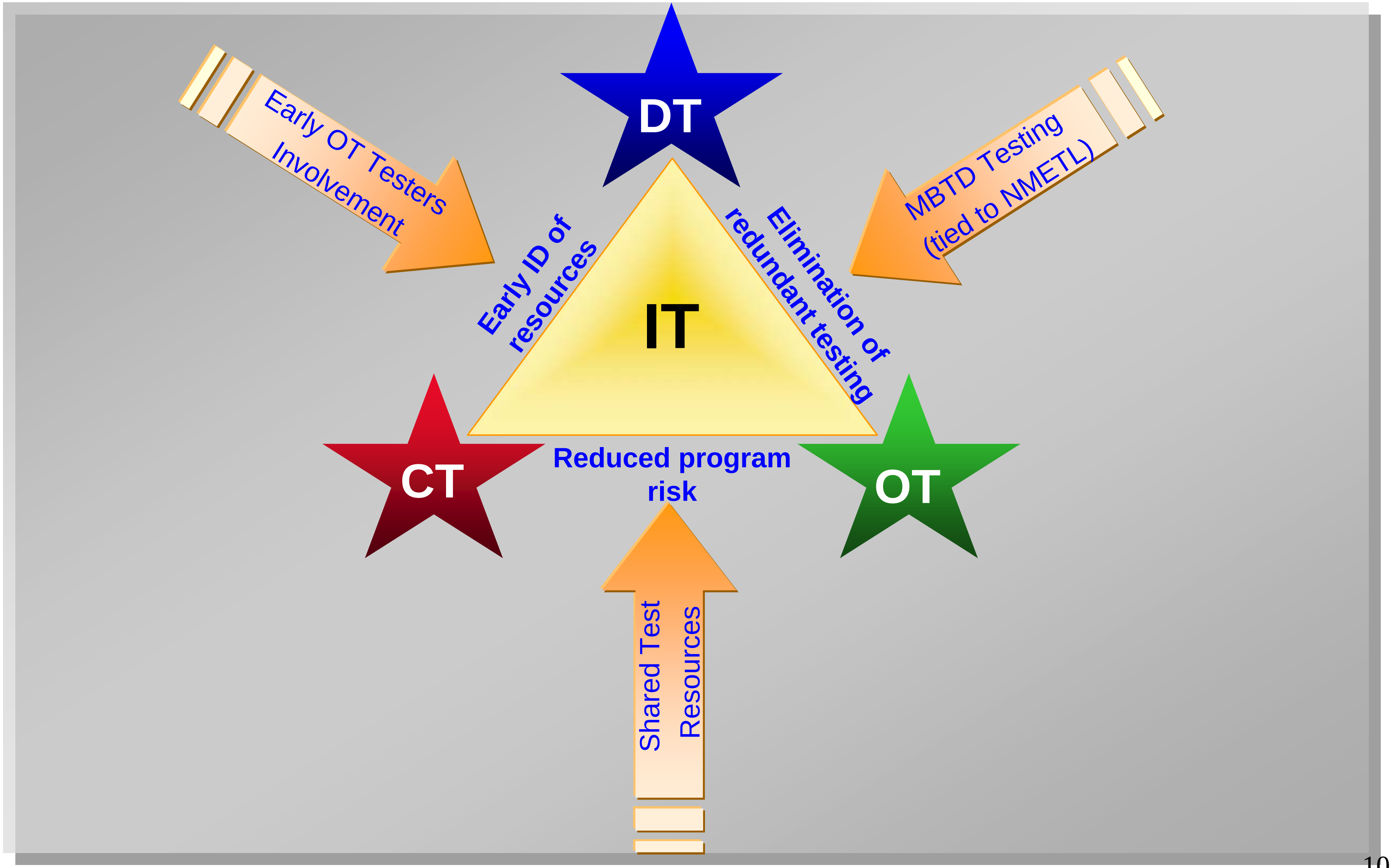
- Define Tasks
- Establish Conditions
- Determine Measures of Success
- Develop Factorial Design
- Create Vignettes
- Develop Detailed Procedures
- Identify Resources
- OT Framework

TEMP and TEST PLAN

Future T&E Cycles



Integrated Test



Integrated Test

"Integrated testing is the <u>collaborative</u> planning and <u>collaborative</u> execution of test phases and events to provide data in support of independent analysis, evaluation and reporting by all stakeholders particularly the developmental (both contractor when appropriate and government) and operational test communities."

Operational Test and Evaluation Force

National Test and Evaluation UV Conference Brief

RDML Stephen S. Voetsch

February 2008
UNCLASSIFIED


505
NAVY

Knowledge Management and Retention

A looming crisis for the unprepared

Presented by

VSE Corporation

Enterprise Excellence

Knowledge Management and Retention

Historical Attrition

- Competition
- Retirement
- Career Change
- Catastrophic Accident

Knowledge Management and Retention

Issues of the 21st Century

- Advanced Technology
- Specialized Knowledge
- Baby Boomer Generation
- Uneven Hiring Practices

Expectation: 30% to 50% Attrition within 5 Years

Knowledge Management and Retention

Knowledge at Risk:

- Historical Products Still Supported
- Networks and Contacts for Problem-Solving
- Complex Systems Corrective Actions
- Unique Diagnostic Capabilities

Usually Not Adequately Documented

VSE CORPORATION
ENTERPRISE EXCELLENCE

Knowledge Management and Retention

Why Is It Allowed to be Lost?

- Critical Knowledge (CK) not Documented
- CK not Shared
- CK not Recognized as Critical or Unique
- Time Required to Document or Share
- The Most Critical is Usually the Most Complex

Not a Matter of Risk – A Certainty

Solving the Problem

Step 1: Identify the CK in the Workforce

Leading Questions:

- What are our core competencies?
- Why have we been able to succeed?
- What sets us apart from the competition?
- What do we do better than anyone else?

Solving the Problem

Step 2: ID Present Method of Storing CK

- May Be Adequate
- Improvement may suffice
- Major Action May Be Needed

Solving the Problem

Step 3: Identify Who Has the CK

- Who Do Managers Rely on Most?
- Can Alternates Perform the Function As Well?
- Peer Reviews
- Who Do Employees Seek Out?

Solving the Problem

Step 4: Develop a CK Storage System

- Many Options Available
- Must Be Tailored to Organization’s Culture
- Must Be Efficient
- Critical Balance

Solving the Problem

Step 5: Gather & Store CK

Difficulty Dependant On:

- Organizational Culture
- Amount of Segmentation
- Time Available
- Resources Allocated
- Number of Individuals with CK
- Amount of CK

Expected Roadblocks

The Knowledge Miser

- Status Achieved Through CK
- May Be Reluctant to Relinquish Status

Knowledge Miser Solution

KM’s Interests Addressed Through:

- Org. Ability to Maintain Long-Term Benefits
- Potential Near-Term Layoffs
- Status Through Knowledge Sharing

Expected Roadblocks

The Distrustful:

- Feels ill-treated by Organization
- Resentful
- No desire to help organization

Expected Roadblocks

The Distrustful Solutions:

- Identify Source of Resentment
- Re-Establish Positive Relationship
- Assign to Project Teams

Expected Roadblocks

The Contractor

- CK Increases in Value Near Retirement
- CK Considered a Commodity
- Give Away Now or Sell Later
- Only Delays the Problem

Expected Roadblocks

Contractor Solutions:

- Exchange CK Prior to Return as Contractor
- Initial Assignment: Clarify process & Methodologies

Knowledge Management and Retention

Knowledge Management Systems

- Training
  - Structured process
  - Results measured & evaluated
  - Significant resource requirements
- Storytelling
  - Informal, casual
  - Social activity

Knowledge Management and Retention

Knowledge Management Systems

- Coaching
  - Provided as needed
  - Growth process
- Exit Interview
  - Most commonly used
  - Least effective

Knowledge Management and Retention

Knowledge Management Systems

- Critical Incident Report
  - Easy implementation
  - Limited application
- Network of Specialists
  - Serious cross-training
  - Mutual support

Knowledge Management and Retention

Knowledge Management Systems

- Exit Interview
  - Most commonly used
  - Least effective
- Mentoring
  - More structured than coaching
  - Dependent on favorable relationships
  - Most effective, most challenging

CK Management & Retention Summary

- Match Culture, System, and Resources
- System Must Be User Friendly
- Resource Requirements Increase with Time
- Management Choice:
  - Develop a System that Captures and Retains CK
  - Re-create CK at a later date
  - Lose the capability

The Four-Element Framework: Progress Towards an Integrated Mission-Based T&E Strategy

Christopher Wilcox

U.S. Army Evaluation Center
Aberdeen Proving Ground, MD

27 February 2008

J:\Plans\Marketing\CG BRFS

Agenda

- Accomplishments
- Four-Element Framework (4-EF) Overview
- Improvements made to the:
  - Mission Element
  - System Element
  - Mission to System Interface
  - Evaluation Element
  - Test Element
- Detailed Development of the 4-EF Execution
- Mission-Based Test and Evaluation Strategy
- Summary

Accomplishments

- Briefed at 23rd NDIA National T&E Conference, 13 March 2007
- CH-47F Case Study (completed)
  - Applied 4-EF to the evaluation of the CH-47F.
  - Modified the construct of the all four elements (mission, system, evaluation and test).
  - Verified the modified element designs by producing a 4-EF designed System Evaluation Plan (SEP).
- Joint Cargo Aircraft Case Study (ongoing)
  - Started application of 4-EF to the evaluation of the JCA.
  - Validated design of the mission and system elements by producing them .
  - Continuing to develop evaluation and test elements on road to producing 4-EF designed SEP.
- Held Mission-Based T&E Strategy Summit (5th-6th Feb 08)
  - Path Ahead: Integrate – Demonstrate - Coordinate

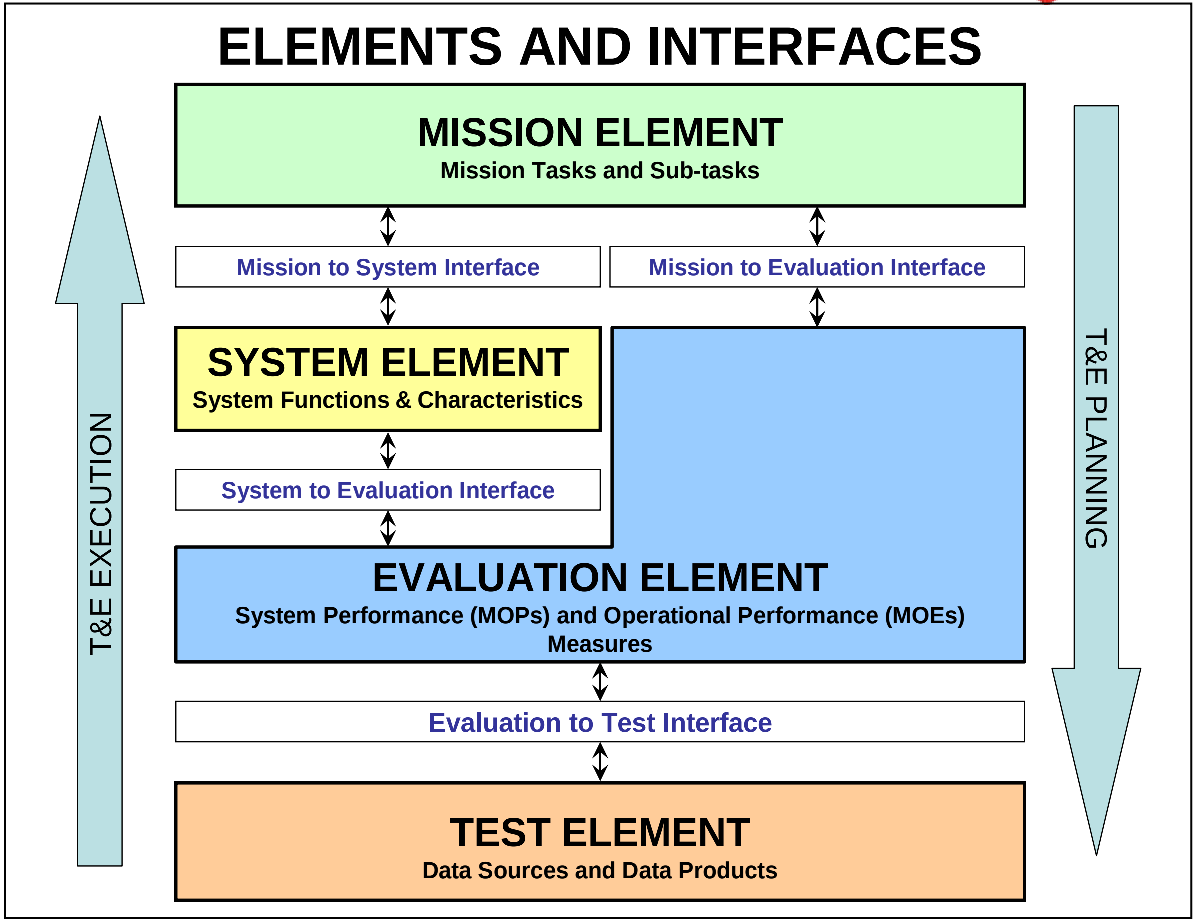
4-EF Overview

<u>Elements</u>

- Mission
  - Mission tasks and sub-tasks.
- System
  - System items, functions and characteristics.
- Evaluation
  - Evaluation measures.
- Test
  - Data sources and products.

<u>Interfaces</u>

- Mission to System
  - How the system supports the mission tasks.
  - Gives operational conditions and linkages.
- Mission to Evaluation
  - How operational tasks are evaluated.
  - Gives operational conditions.
- System to Evaluation
  - How system performance is evaluated.
- Evaluation to Test
  - How the data supports the evaluation.



<u>Traces</u>

- <u>Planning</u> starts at the mission element, progresses through the system and evaluation elements and ends at the test element.
- <u>Execution</u> of the T&E effort starts at the test element, progresses through the evaluation and system elements and ends at the mission element.

Mission Element

Purpose

- To describe unit mission and tasks required to accomplish that mission.

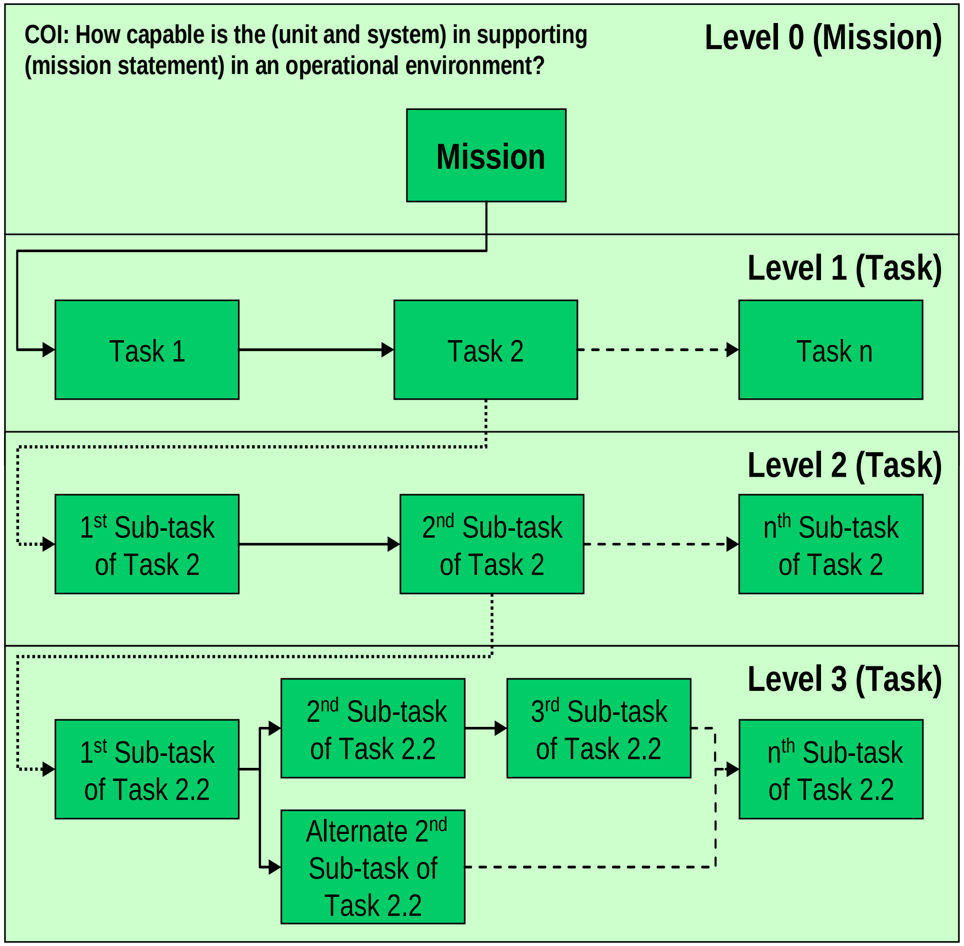
Components

- Task: A task is defined as a discrete action that the unit (system and its operators) must perform in order to accomplish its mission. For example: communicate with ground unit.

- Task Levels: Orderly breakdown of the mission into tasks and sub-tasks.

Three types of tasks were identified in order to assess impact of the task on overall mission performance.

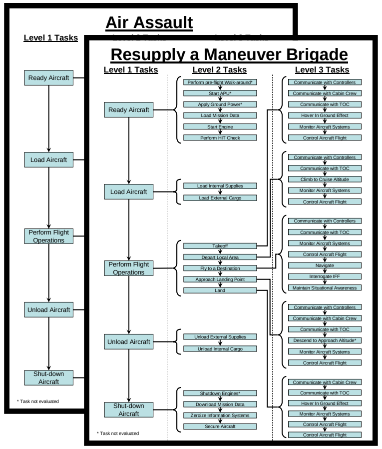
- **Mission Execution Tasks**
- **Conditional Mission Tasks**
- **Mission Enabling Tasks**



Mission Element
Task Type Definitions

Mission execution tasks.

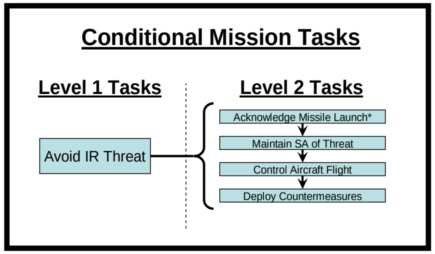
- Tasks that describe a discrete action that the unit (system and its operators) must perform in order to accomplish its main mission.
- Examples: Navigate, ID Target, Send BDA message, etc.



Aggregated into **Effectiveness**

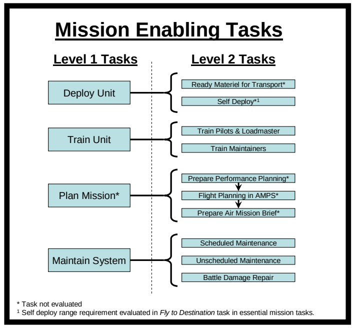
Conditional mission tasks.

- Tasks that are performed during the mission that become required due to some influencing condition. They are not normally required to successfully execute the mission.
- Examples: Avoid threat missile, Extinguish engine fire, etc.



Mission enabling tasks.

- Tasks that enable the mission execution and conditional tasks to be performed. They usually occur before or after the mission.
- Examples: Training, Maintain, etc.



Aggregated into **Suitability**[1]

1. When aggregated along with system enabling characteristics.

System Element

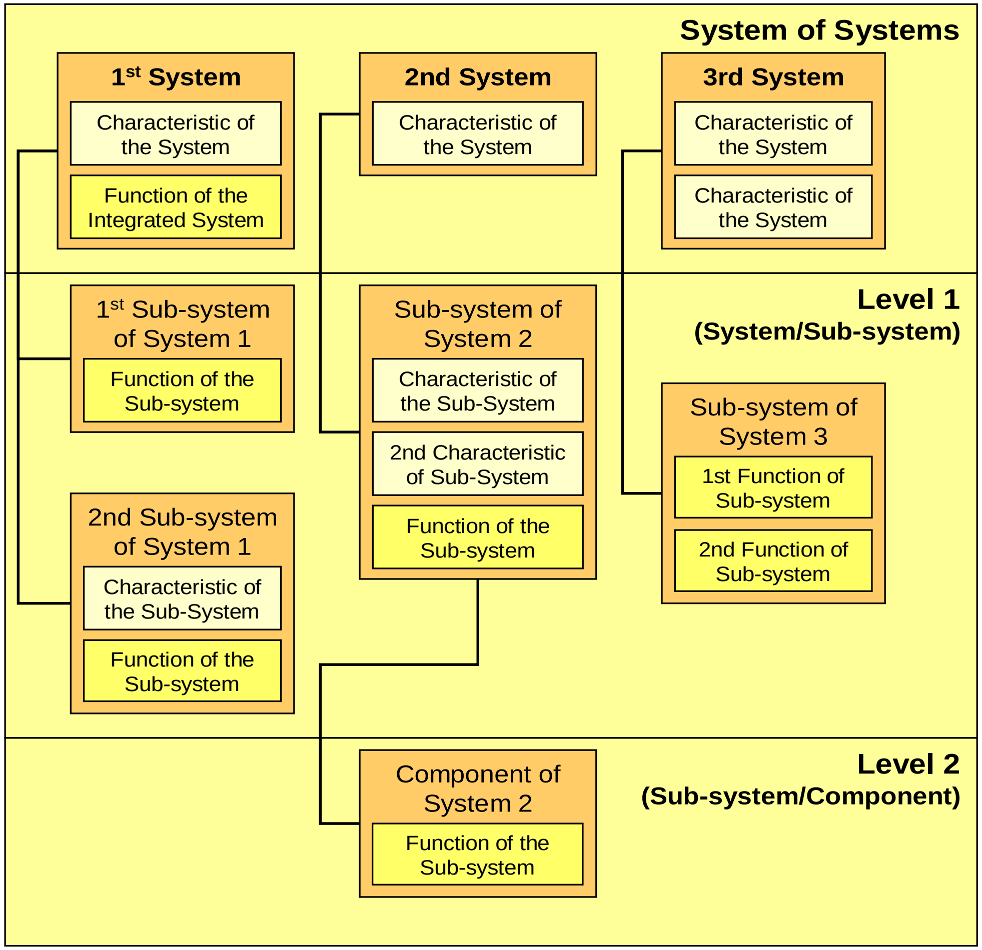
<u>Purpose</u>

- To describe the system and the system functions and characteristics.

<u>Components</u>

- System Items: Makeup of the system and sub-systems.

- System Functions: Description of the function an item must perform in support of the mission.



Added system "characteristics" to accommodate suitability attributes (reliability, maintainability, etc.).

- **System Characteristics: Description of a particular quality of the system that affects whether the item can perform a function.**

Mission to System Interface

Purpose

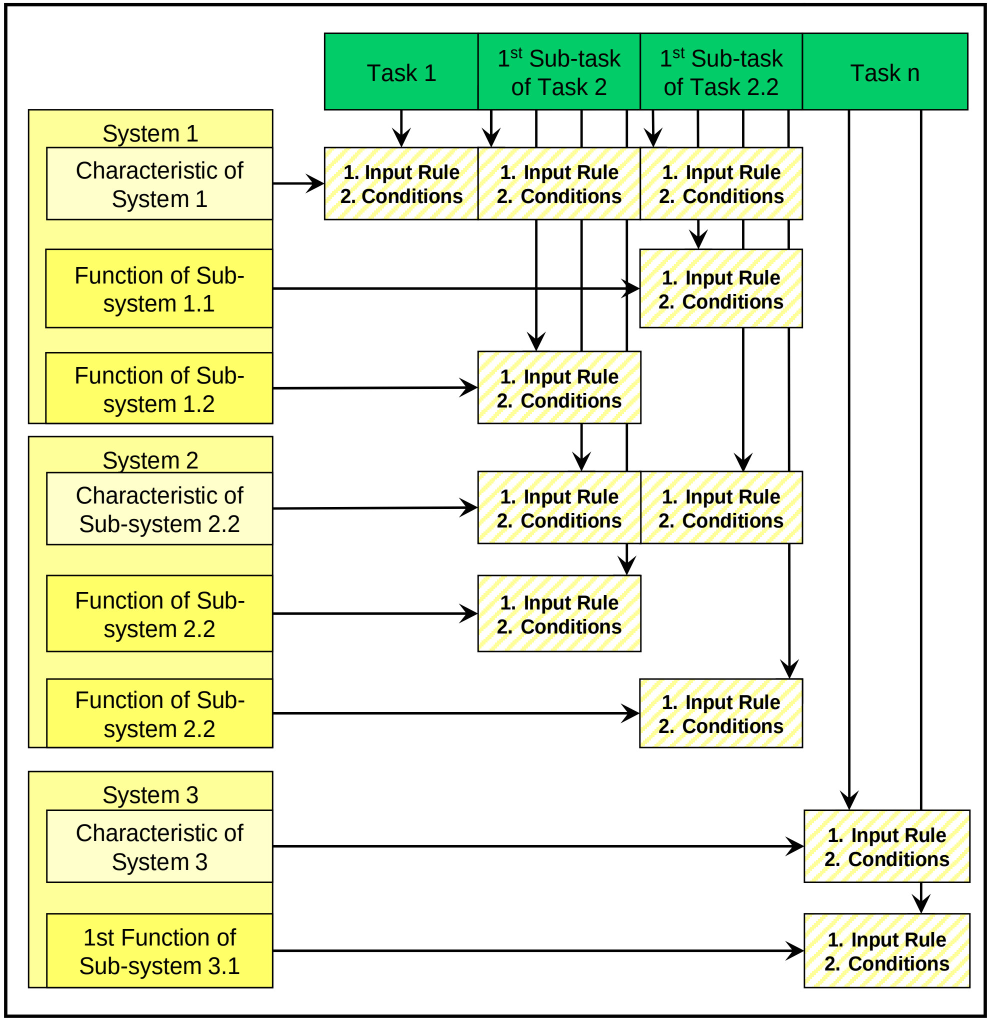
- To describe how the mission tasks relate to the system attributes (functions and characteristics).

Components

- Input Rule: Description of how the system items relate to the mission task. Uses logical input rules, such as AND and OR to describe links to more than one system or function.

- Conditions: Description of the physical, military, and civil variations that affect performance of a task. Comprise the operational test conditions used in DT and OT. For example; weather conditions, countermeasures, urban environment, etc.

Some system characteristics will affect all tasks. These are labeled **"mission enabling characteristics" and are aggregated with mission enabling tasks to assess suitability.**



Evaluation Element

Purpose

- To describe the evaluation measures and how they relate to mission tasks and system attributes.

Components

- Standard: Acceptable performance of the system attribute or mission task in terms of the MOE/MOP.
- Link to System-focused COI/C: Column in the evaluation element that identifies which MOE/Ps are used to evaluate the system-focused COI/C.

Re-aligned evaluation measures to distinguish evaluation of system performance from task capabilities and facilitate planning.

- **Measure of Effectiveness (MOE): Measure used to evaluate operational capability (task capability).**
- **Measure of Performance (MOP): Measure used to evaluate system attribute performance.**

COI: Does the (system) perform (system capability)?			Task 1	1st Sub-task of Task 2	1st Sub-task of Task 2.2
Standard for MOP	MOP for Characteristic of System 1	Characteristic of System 1	Input Rule Conditions	Input Rule Conditions	Input Rule Conditions
Standard for MOP	1st MOP for Function of Sub-system 1.1	Function of Sub-system 1.1	Input Rule Conditions		Input Rule Conditions
Standard for MOP	2nd MOP for Function of Sub-system 1.1				
Standard for MOP	MOP for Characteristic of System 2	Characteristic of Sub-system 2.2		Input Rule Conditions	Input Rule Conditions
Standard for MOP	MOP for Function of Sub-system 2.2	Function of Sub-system 2.2		Input Rule Conditions	
Standard for MOP	MOP for Function of Sub-system 2.2	Function of Sub-system 2.2			Input Rule Conditions
Standard for MOE	MOE for Sub-task of Task 2			Conditions	
Standard for MOE	MOE for Sub-task of Task 2.2				Conditions

System Evaluation Plan
Evaluation Planing Construct

Current Evaluation Construct

ESS
- All results aggregated into:
  - is/is not effective,
  - is/is not suitable, and
  - is/is not survivable.

COI/Cs
- ESS evaluation based on **critical issues and criteria**.

MOE
- MOEs are a roll-up of MOPs.
  - Can be operational in nature.
  - Sometimes technical in nature in order to support criterion.
  - Not necessarily "measures" since they are aggregations.

MOP
- MOPs are tested and evaluated.
  - Sometimes technical in nature
  - Sometimes operational in nature. (OT measures).

4-EF Evaluation Construct

Mission
- Capabilities and limitations presented at the mission level.
- **Can be aggregated into ESS**.
  Effectiveness = execution & conditional tasks.
  Suitability = enabling tasks & characteristics.

Level 1 Task
- Mission capabilities and limitations **based on execution of ALL tasks** necessary to accomplish the mission.
- COI/Cs addressed through evaluation of tasks.
  - COIs are a sub-set of tasks or system function/characteristics.

MOE
- MOEs are a measure of task accomplishment.
  - **Always operational in nature**.
  - Truer to DAU definition of a MOE; "Measure designed to correspond to accomplishment of mission objectives and achievement of desired results."

System & Function/ Characteristic

MOP
- MOPs are a measure of system performance.
  - **Always technical in nature**.
  - Truer to DAU definition of a MOP; "Measure of a systems performance expressed as speed, payload, range, time on station, frequency, or other distinctly quantifiable performance features."

Level 2 Task
- Lower level tasks evaluated to determine operational and system performance on overarching task.
  - **Allows T&E at right level of fidelity**.

Test Element

Purpose

- To describe the data products, the sources of the data products, and how they relate to the evaluation element's MOPs.

Components

- Link to MOPs: Description of which data products support which MOPs.
- Data Products: Specific data packet obtained though a data source satisfying a MOP data requirement.
- Data Sources: The specific source of a data product.

Time Phased

Contractor Test		M&S	Developmental Test			OT Event #1		M&S	OT Event #2	M&S	← DATA SOURCE
Data Product #1	Data Product #2	Data Product	Data Product #1	Data Product #2	Data Product #3	Data Product #1	Data Product #2	Data Product	Data Product	Data Product	
	X			X							MOP
			X								MOP
		X						X		X	MOP
X					X						MOP
						X	X				MOE
							X				MOE

Test element "time phased" to **facilitate assessment of T&E program** and to describe an integrated T&E plan where the **most appropriate data is used at the most appropriate time**.

System Evaluation Plan

Test Planning Construct

Essential Elements

Overview
- Types of data sources, overall summary & schedule

Data Source
- Source description (test, analysis, demonstration or inspection).
- **Measures Supported**
  - Measure description, analysis leading to **data elements**, conditions leading to **DOE**.
- **Data Products**
  - Description of deliverables (reports, databases, etc.) supporting delivery of data elements.

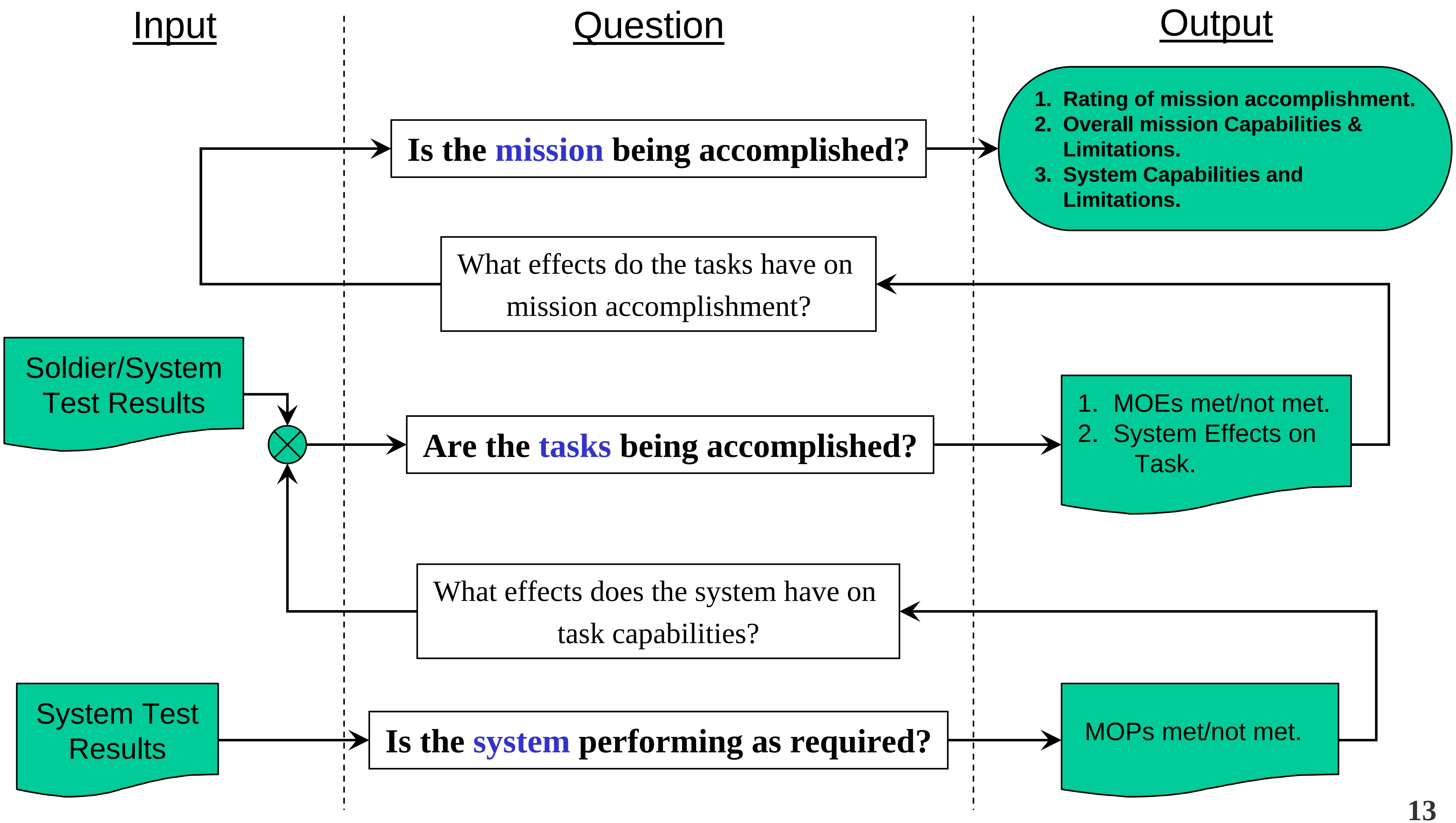
•
•
•

4 Basic Types of Data Sources

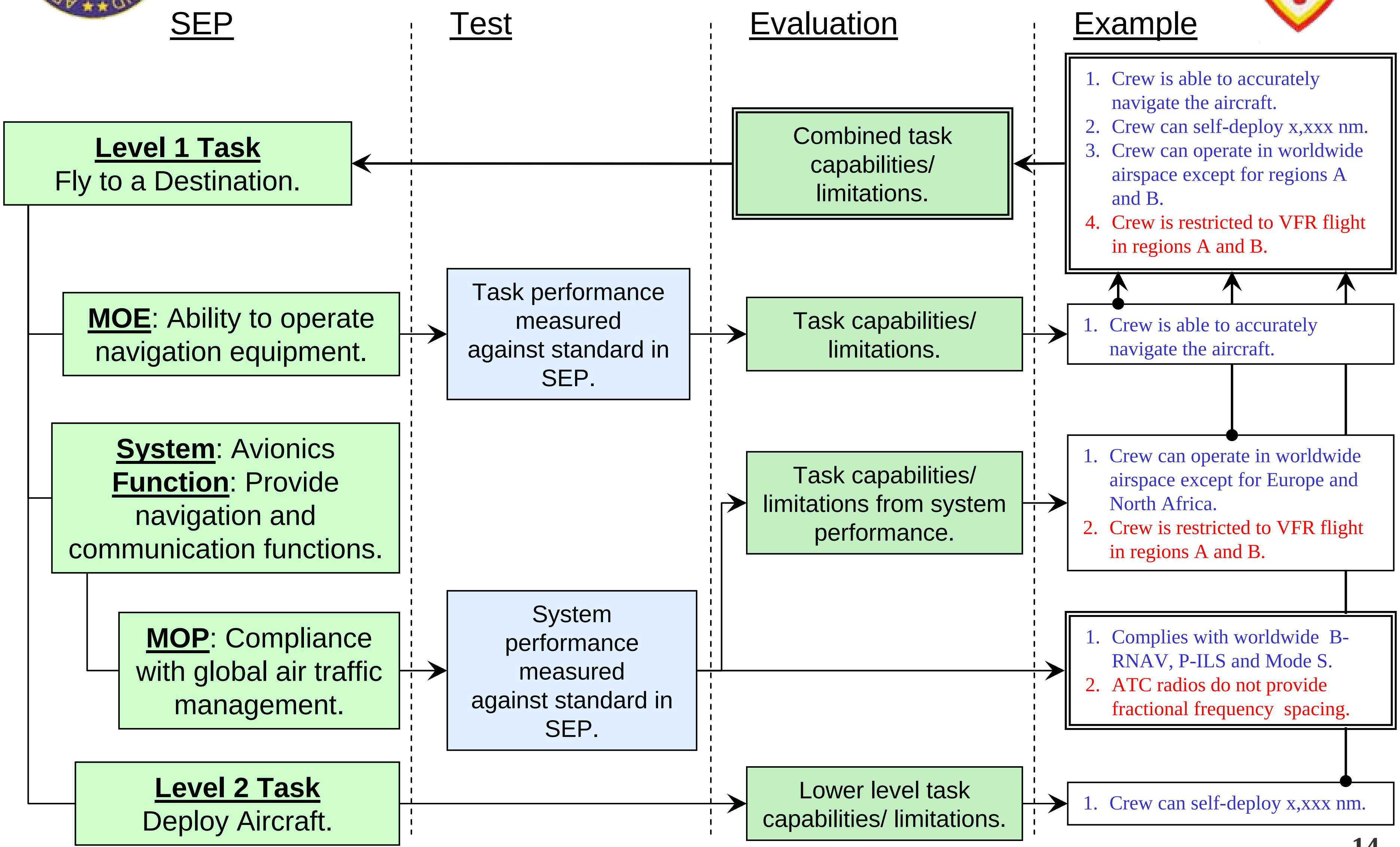
1) Test Events
   - 1a) Developmental Test Events
     - Contractor DT
     - Government DT
   - 1b) Operational Test Events
2) Modeling, Simulation & Analysis
3) Demonstration/Inspection Events
4) Other Agencies' Reports/Certifications

4-EF Execution

(AKA "The 3 Questions")



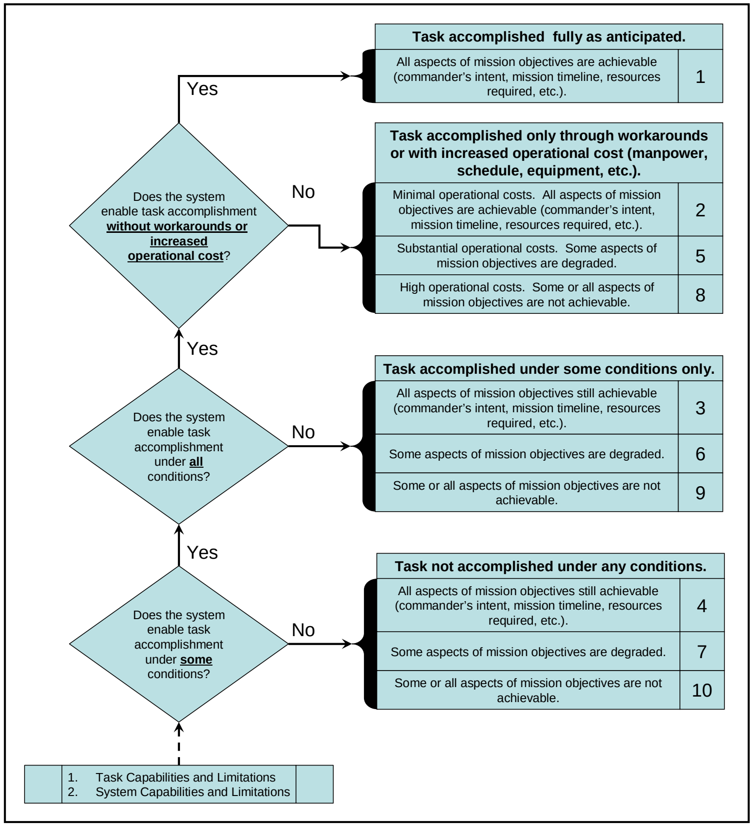
4-EF Execution Example



4-EF Execution

Mission Capability Scale Ongoing Development

- Each mission task is examined in two areas:
  - Does the system support task accomplishment, and
  - Does the task support mission objectives & required capabilities?
- Rating scale is similar to Cooper-Harper or Bedford Workload Scales.
- Rating scale not sequential in order to reflect higher importance of task meeting mission objectives vs. system meeting task requirements.
- Lower the number, the better the mission performance.



Concept being assessed for:

- **Functionality: Can the ATEC system team apply the methodology?**
- **Quality: Are the results repeatable and meaningful?**

Mission-Based T&E Strategy Study Group

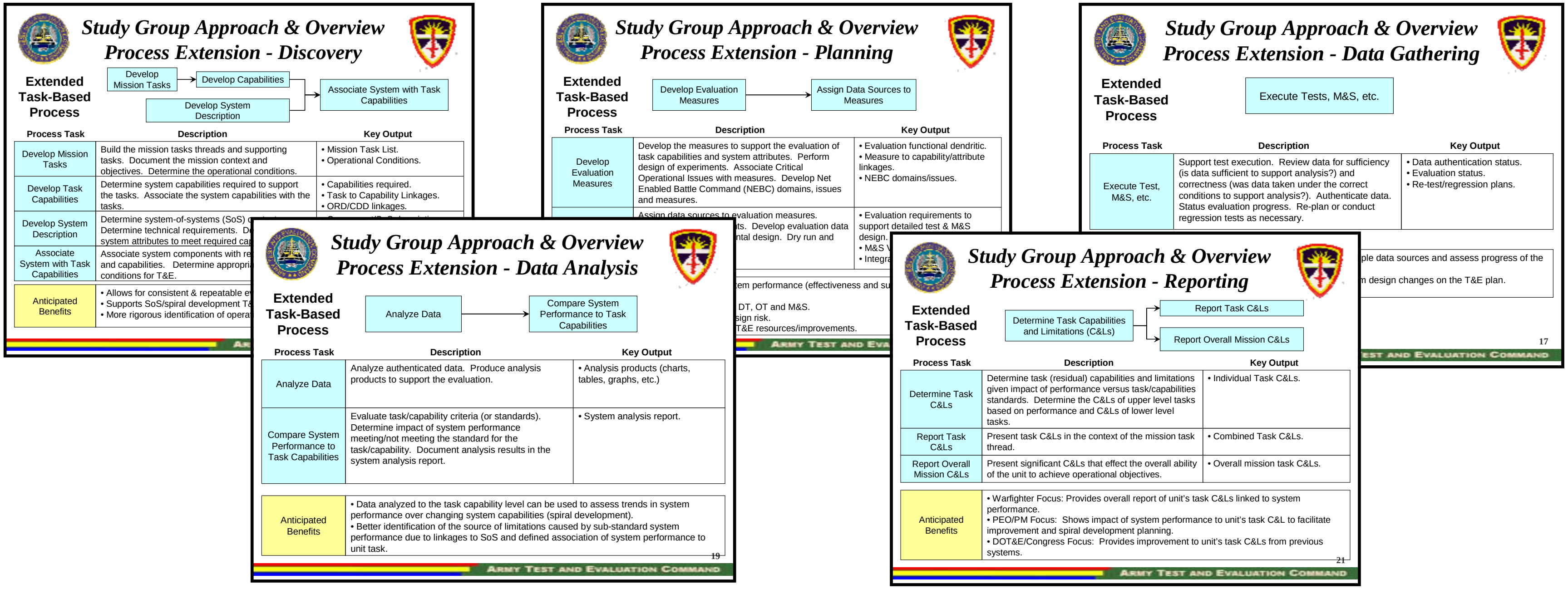
- Study group was formed in early December 2007. Participants included:
  - U.S. Army Test and Evaluation Command,
  - U.S. Army Evaluation Center,
  - U.S. Army Research Laboratory – Survivability/Lethality Analysis Directorate,
  - U.S. Army Research Laboratory – Human Research & Engineering Directorate,
  - U.S. Army Materiel Systems Analysis Activity, and
  - DOT&E, Joint Test and Evaluation Methodology

- The group examined four major efforts in detail: Four Element Framework (AEC), Net Enabled Battle Command (ATEC), Missions and Means Framework (ARL), Capability Test Methodology Measures Framework (JTEM).

- Approach:
  - Integrate the various concepts with the **goal of developing a consistent, repeatable and robust integrated T&E methodology for evaluating the capabilities, limitations and contributions of networked system of systems in improving a U.S. force's ability to accomplish their assigned tasks**.

Mission-Based T&E Strategy
Study Group Results

- Results Achieved
  - Group Consensus: An evaluation focused on the **mission tasks** will show causality of individual system performance on capabilities and limitations provided by the system-of-systems (to include the contribution of the networked-enabled command and control).
  - Group Focus: Development of integrated mission-based T&E process.



Mission-Based T&E Strategy Path Ahead

Mission-Based T&E Strategy Summit held 5th-6th Feb 08.

- Briefed out study group results to senior steering group.
- T&E focused on the mission tasks is correct path ahead
- Future efforts should focus on…
  - Development of a common definition of terms: Common language needs to be developed to ensure understanding across organizations.
  - Demonstration of the integrated process: The process needs to be demonstrated to validate the concept and to show that the anticipated benefits can be realized.
  - Coordination of the concept with the rest of the acquisition community: Concept is best executed with a coordinated effort between requirements generator, materiel developer, and T&E Community. Also, lessons learned should be shared with others working similar concepts.

Summary

- Four-Element Framework has evolved through case study application of the methodology.
  - More robust mission element.
  - Suitability attributes addressed.
  - System evaluation plan format developed.
  - Test element re-designed to facilitate assessment of T&E strategies.
  - Methodology for mission task capability roll-up developed.

- Path ahead for mission-based T&E lies in coordination with the acquisition community.
  - Development of common terms.
  - Demonstration of an integrated process.
  - Open discussions with requirement, materiel developer, and T&E community.

ARMY TEST AND EVALUATION COMMAND

TRUTH

U.S. ARMY EVALUATION CENTER

UNDERSTANDING

Author

Christopher M. Wilcox

U.S. Army Evaluation Center
ATTN: TEAE-AV-A
4120 Susquehanna Ave.
APG, MD 21005
(410) 306-0475
chris.wilcox1@us.army.mil

Acronym Chart

AA	Additional Attribute
AKA	Also Known As
ATC	Air Traffic Control
AV	All View (slide 4)
AV	Air Vehicle (slides 11, 13, and15)
CDD	Capabilities Development Document
COI	Critical Operational Issue
CPD	Capabilities Production Document
DAG	Data Authentication Group
DoD	Department of Defense
DT	Developmental Test
GCS	Ground Control Station
JCIDS	Joint Capabilities Integration and Development System
KPP	Key Performance Parameter
MER	Mission Evaluation Report
METT-TC	Mission, Enemy, Terrain, Troops, Time and Civil
MOE	Measure of Effectiveness
MOP	Measure of Performance
OA	Operational Area
OT	Operational Test
OT&E	Operational Test and Evaluation
OV	Operational View
RSTA	Reconnaissance, Surveillance & Target Acquisition
RT	Remote Terminal
SATCOM	Satellite Communications
SV	Systems View
T&E	Test and Evaluation
T/O	Takeoff
TM	Telemetry
TV	Technical View
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
VFR	Visual Flight Rules